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Steel Tanks for Water Works Systems

Probable Trend in Development of These Structures

By GEORGE T. HORTON
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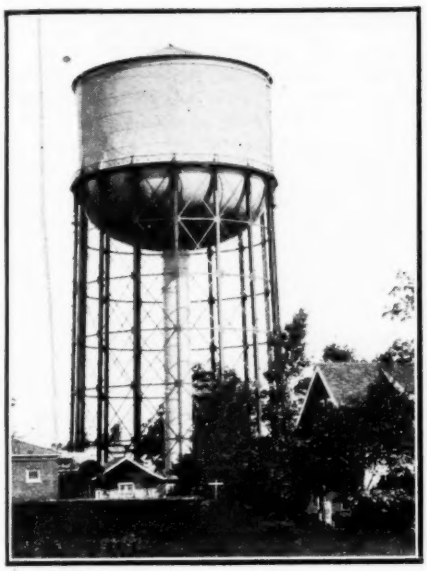


One Million Five Hundred Thousand-Gallon Elevated Tank Built for Royal Oak, Mich. It is Part of the Woodward Ave. Water System Project Serving a Large Section of the Detroit Metropolitan District

IN 1893 there was illustrated in the engineering press the design of a hemispherical bottom elevated steel tank built at Laredo, Tex. This structure was designed by Mr. Edward Flad, consulting engineer of St. Louis. Mr. Flad has told me that this design was entirely original. To him, therefore, should be accorded all credit for the original conception of a steel tank with a suspended bottom.

Interested as I then was in the construction of steel standpipes and in steel towers for the support of wood tanks, I could quickly grasp the possibilities in a combination of the two. It did not require any very profound calculations to show that if the upper part of the standpipe, which provides the only effective storage, could be supported on a steel tower it could be done at far less expense than that necessitated by building the standpipe down to the ground and providing the necessary foundations.

Construction in the decade following the year 1895 was in a transition stage. The elevated tank immediately appealed to some engineers; others insisted upon wood tanks; many would have nothing but a standpipe. Old records will show numerous examples of standpipes built only 10, 12, and 14 ft. in diameter, over 100 ft. high, for which was paid more than elevated tanks of approximately double the effective capacity would have cost.

Arguments as to the relative merits of elevated tanks and standpipes no longer exist. Decision is now reached upon the engineering opinion as to the best and most economical method of obtaining the desired storage.

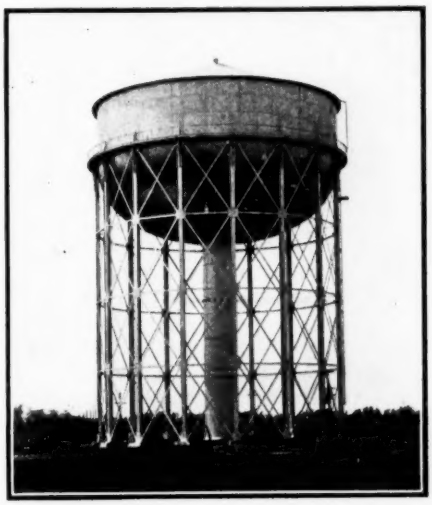
Most Economical Form.—The most economical form of a simple storage tank—by which I mean a tank supported directly upon the ground or upon foundations if necessary—is one in which the height and diameter are approximately the same; provided the height does not exceed 50 ft. If a greater capacity is desired than can be contained in a tank 50 ft. in diameter and 50 ft. high, then the diameter only should be increased to obtain the desired capacity.

This, to be sure, is only a general statement, subject to several variable factors such as thickness of bottom and roof, allowed unit stresses, and cost of foundations.

The oil industry presents the greatest demand for storage tanks. Quite elaborate studies in connection therewith indicate the most economical height to be from 46 ft. to 48 ft. These tanks are universally built directly upon the ground, the only foundation work usually done being the removal of the top soil and leveling of the exposed surface.

I think it not amiss to call to your attention this fact, that most of the storage tanks of the world are built with so little foundation work, and that I see no reason for the construction of such extensive foundations as are usually placed under water tanks.

Elevated steel tanks of earlier years were practically all built with hemispherical bottoms. A few conical bottoms were tried out and discarded except in special instances, the most notable being those for railroad service.



One Million-Gallon Elevated Tank at Springfield, Ill. It is 72 Ft. in Diameter, Has a 17-Ft. Shell Height and a Total Range in Head of Only 37 Ft. 8 In.

The Ellipsoidal Bottom.—As demands for ever increasing capacities developed, certain inherent difficulties in the hemispherical bottom tank appeared. If we endeavored to limit the total height of a tank in order to prevent an undesirable range of head, the diameter would become so great that the bottom would be out of all proportion to the cylindrical part of the tank: for example—should be called upon for a hemispherical bottom tank containing 1,000,000 gal. and having a total height of 40 ft., the tank would be all bottom; because 1,000,000 gal. is the capacity of a hemisphere 80 ft. in diameter. The same condition would prevail in an effort to store 2,000,000 gal. within 50 ft. We obviated these difficulties, in part, by making an ellipsoidal bottom, the vertical depth of which is but half that of the hemisphere.

An ellipsoidal bottom tank answers very well in capacities up to 500,000 gal., constitutes an improvement in all sizes, and is the explanation of why so many of our large tanks have been so built. Unfortunately some of the stresses in an ellipsoidal bottom are compressive rather than tensile. These

compressive stresses in tanks of over 1,000,000 gal. capacity are of sufficient magnitude to necessitate an increase in the depth of the bottom, causing an increase in the range of head, and thus setting up a vicious cycle. More simply stated—when there is a limit to the total height of a tank, there is also a limit to the size of that tank if it be of the suspended bottom type.

It is not practical to build a hemispherical bottom tank containing more than 175,000 gallons, nor an ellipsoidal bottom with more than 300,000 gallons, the total height in each case being limited to 25 ft. While we have not as yet been called upon to build many tanks so limited, it is not unlikely that the future will bring such calls.

Advantage of Elevated Storage for Larger Systems.—Only recently have those advantages of elevated storage, known to obtain in a small plant, been considered applicable to our larger systems. (Witness the paper on this subject presented by Nicholas S. Hill at the Buffalo meeting of this association; also one presented to the Rocky Mountain Section by Donald H. Maxwell, of the firm of Alvord, Burdick and Howson; as well as many actual installations, such as those at Detroit, Charleston, San Antonio, Tampa, and others.) I am told that for such service the less the variation in head the better. Theoretically, the maximum head should also be the minimum; or perhaps better stated, the minimum head required should also be the maximum.

Pumps operate at their highest efficiency against a constant head. Pumping against additional head involves useless expenditure of energy; and where power is purchased, easily reducible to exact figures.

These conditions show that in determining the proportions of a tank, operating costs should be considered. In any city where elevated storage is under consideration, certain practical problems are at once presented to the engineer in charge. Studies must be made to determine to what extent it may be economical to limit the range of head. Once that limit has been fixed, there arises the question as to whether the storage will be better provided by the installation of many small tanks, or by fewer large ones. Very likely it will be found that the larger units are preferable; furthermore, that the size of these units will exceed the limit of any possible suspended bottom tank.

Suspended Bottom Tanks.—I imagine that there is prevalent an impression that a suspended bottom tank is the only practical—at least the most economical—form. For many years I so believed. This impression is true as regards all ordinary sizes. It is also true if the height of a tank be unlimited. Not otherwise.

The fundamental economies in suspended bottoms obtain by making use of the inherent strength in the bottom plating, and in lesser degree to the fact that a hemisphere or ellipsoid requires the least surface to contain a given volume.

The suspended bottom, due to the refinements required in its construction, is the most expensive part of a tank, and as its size is increased greater stresses necessitate heavier material. It is evident, therefore, that a point will be reached at which the additional material required in a suspended bottom will more than offset the cost of beams and girders necessary to support a flat bottom. At this point the economies in a suspended bottom tank disappear.

I have recently studied this subject sufficiently to announce that tanks over 1,000,000 gal. in capacity may be built with flat, or approximately flat, bottoms which will cost less than tanks of the same capacity with suspended bottoms. Stated more specifically, and of course referring to equal capacities, I am sure that an elevated tank with an approximately flat bottom, the height of which will not exceed 25 ft., can be built for less than can an elevated tank with suspended bottom, the total height of which will be more than 50 ft. I presume you understand that my references to the height of a tank apply to the tank only, and not to the height of the supporting tower.

There is seemingly a growing demand for tanks limited in height in order that the range of pressure may be reduced. I know of two tanks built during the past year—each 1,000,000 gal. capacity, one of which is only 8 ft. high, and the other 24 ft.; both so constructed for the reasons cited.

I think this discovery, viz., that we may radically change the form of our larger tanks from that heretofore used, to one which will reduce operating charges and at the same time effect an actual first cost saving, is most important. It will, I hope, prove of practical benefit to those members of this association who have before them the problem of elevated storage.

Acknowledgment.—The above is an abstract of a paper presented at the 49th annual convention of the American Water Works Association at Toronto, Ont., June, 1929.

New Industrial Water Rate at Fort Worth, Tex.—A new industrial rate on water was authorized in July by the Fort Worth City Council. It is for consumers "with a weighted average of 4,000,000 cu. ft. or 30,000,000 gal. per month," and on this basis will cost 12½ ct. per 1,000 gal. The table for the ordinance to be drawn covering the new schedules: For the first 350 cu. ft. $1, next 24,650 cu. ft. 22½ ct., next 25,000 cu. ft. 17½ ct., next 1,374,575 cu. ft. 12½ ct., next 2,575,425 cu. ft. 7½ ct., all over 4,000,000 cu. ft. .934 ct.

Sanitation of Automobile Tourist Camps

The safeguarding of the health of automobile tourists, both on the roads and in the camps, has become an important public health problem. As early as 1925 it was estimated that in 35 states there were more than 3,000 camps attended by over 2,000,000 campers. In 1928, it was estimated that, in California alone, there were 1,400 automobile camps. In other states, particularly those with well advertised scenic areas, there were probably several thousand others. Investment in camps of all kinds in the state of Maine has been estimated to exceed $5,000,000. Much has been done within recent years to improve tourist camps, but there is yet much more to do. For example, in one state in 1926, there were 233 camps inspected, and only 104 of these could be approved.

The problem is not a simple one but involves three important factors: First, an intelligent understanding of the situation by the people; second, the cooperation of state and local authorities, and the support of official and voluntary organizations; and, third, the most important, the fixing of the responsibility for the maintenance of sanitary conditions.

In many states the responsibility for the sanitation of tourist camps has been delegated to state health officers by law, and in others, those agencies have undertaken it without express authority. In a few states where the state agency is doing the work, part or all of the authority has been transferred to district or local agencies or groups. Unfortunately, there are a few sections in which the responsibility for the work has not been positively assumed by any particular department or group. However, these sections are in the minority, because within the last few years much careful thought and diligent effort has been given by health authorities as a whole to making living conditions for campers as nearly suitable for them as possible.

Such state agencies as have started tourist camp sanitation work have usually set up regulations governing the proper construction and maintenance of this kind of camp. The three principal items in any set of regulations might be given as follows: (1) Proper camp location; (2) Safe and adequate water supply; and (3) Safe and efficient waste disposal.

What is the effect of location on a tourist camp-ground? This question might be sub-divided as follows: (1) Is the site of ample size? (2) Is it provided with a reasonable amount of shade and natural shelter? (3) Will the soil readily absorb and remove water? (4) Is the site accessible to the tourist? (5) Are utilities available from the city, and, if not, are conditions such as to permit the installation of the necessary facilities?

Latest Developments in Asphalt Paving Practice

Subgrades—Base—and Wearing Surface

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A DISCUSSION of this subject should not be confined to asphalt wearing courses, because an asphalt pavement, in common with all others, must have an adequate base which in turn superimposes a subgrade, good, bad or indifferent. Bases may be of several distinctly different types structurally and likewise subgrades may, and frequently do, vary greatly within the limits of a given project. Thus we find our discussion encompassing developments in base practice and subgrade classification and treatment.

Subgrade.—Fundamentally the subgrade should be considered before the base and surfacing are designed, because the nature and bearing capacity of the soil may control the choice of both base and surfacing. Poor subgrade may respond to drainage or treatment readily and cheaply so that it will be the equal of good subgrade, or it may require such extensive treatment as to warrant spending more on the pavement and little or nothing on the subgrade. However, reasonably good subgrade support is so basic as to render doubtful its neglect in favor of expensive pavement in the vast majority of cases. There is even some doubt as to whether it should ever be neglected in the light of expensive maintenance and reconstruction in years to come. In any event, subgrade is so important that every operation depends upon its character.

One large project recently investigated, included a variety of conditions none of which has been taken into account in designing the pavement. Both top and base had followed arbitrary standards of thickness and mixture that were quite satisfactory where drainage was good and subgrade support ample, but failed miserably when conditions changed suddenly within the project.

When the Drainage Was Neglected.—A considerable cut was made at the top of a hill adjoined by a heavy fill diminishing to zero in a few hundred feet, from which point on for a mile or more the street passed through a very flat, poorly drained section in which water stands in great ponds during the spring and fall seasons. The pavement is not on a fill through this section, which means that the concrete base is saturated a great portion, if not all, of the time and especially during freezing weather. Hence in a period of only a few years, the base has failed in the cut from lack of proper intercepting drainage, on the fill from settlement, and in the flat section from disintegration of concrete due to freezing of saturated base. Cores taken from this project, together with a careful study of subgrade conditions, prove conclusively what has happened. At no point has the sheet asphalt top failed except as it has finally followed the broken or settled concrete base. Thus an asplant pavement has failed through no fault of the asphalt and a concrete base has failed because its subgrade support was not uniform in one case and in the other because it was saturated.

Obviously drainage would have eliminated this extensive failure except that caused by fill settlement, in which case the fill was too new at the time of construction. No pavement of economical design is capable of withstanding such extremely adverse conditions.

Classification of Soils.—Recent developments in subgrade investigations and soil studies have provided comparatively simple means of classifying soils with respect to bearing power and drainageability together with various means of subgrade treatment such as:

1. Porous layers on certain soils.
2. Insulating layers of fine, granular materials to prevent soft soils from working up into macadam bases, or porous sub-bases.
3. Bituminous treatment to break up capilarity, and to prevent fine soils from working up into macadam bases.
4. Compacted layers of gravel, stone, slag, etc., to correct lack of uniformity of subgrade support.
5. Drainage to remove moisture from wet areas, and to prevent wetness by intercepting flow from water-bearing strata.

Research work now in progress promises to develop much more valuable knowledge of subgrade performance.*

Base.—Pavement bases must transmit loads to a subgrade. The subgrade is essential and must finally carry the entire load of traffic. In the subgrade is good and of high supporting capacity, the base or foundation course may distribute the load over a comparatively small area without danger of rupture of the pavement base or surfacing. As the load bearing capacity of the subgrade diminishes or traffic loads increase, the foundation must distribute load over a greater area in order to avoid base failures. This becomes true, however, only when the danger point is approached, and is not an arbitrary rule, but is entirely relative to the actual capacity of the subgrade and traffic loads.

As has been shown above, correction of defective subgrade is basic, and should be abandoned only after most careful diagnosis, if at all. But even fairly good subgrades differ in capacity, so that arbitrary laws governing base type and thickness for a given traffic load cannot be laid down. Thus a thin 3-in. or 4-in. base may be ample for one subgrade, while a 5-in. or 6-in. might be required for another, etc. Likewise a macadam base may be entirely ample for one subgrade and entirely inadequately for another unless subgrade is artificially stabilized or base thickness is increased beyond possibly an economical limit.

Old Roadbeds as Foundations.—Traffic bound bases, such as old roadbeds, are nearly always excellent foundations for two very substantial reasons; they are thoroughly compacted and free from further settlement, and they are capable of carrying the traffic even though they may fail or have passed their useful period as wearing surfaces. It is because of these important economic reasons that resurfacing has become so popular. It has thoroughly demonstrated the folly of destroying a present investment for a new one of doubtful economy. Likewise stage construction, or progressive development of pavement commensurate with present needs while simultaneously laying in a store of valuable assets in the nature of future base for a surface of the first order when such shall be required, is constantly impressing more and more engineers with its soundness. Wide awake municipal engineers have recognized the economy of such development for many years, but are frequently prevented from utilizing it because of legal difficulties attending special assessment work. Several eastern states have employed it with outstanding success, likewise the state of Michigan is doing the same thing in connection with gravel and macadam roads.

Such construction marks one of the greatest of recent developments in asphalt paving practice and affords one of the most fertile fields for further progress.

Black Base.—Black base cannot be properly called a recent development; it is actually one of the oldest types of base in the country. However, in its present advanced state, it can be called one of the most important developments

*Reference is made to the valuable discussion of this subject by C. A. Hogentogler, in Proceedings of American Road Builders, 1929, and the May issue of "Public Roads."

in recent asphalt paving practice. Having been a close student of this type of construction for many years, I do not know of a single instance where it has failed of performance and that is something which cannot be said of any other type of base. True, it should not be employed in utter disregard of exact type (premixed, hot or cold, penetration, mixed-in-place, etc.) thickness, character of subgrade and drainage, but, taken "catch-as-catch-can," it has a remarkable record of performance.

Sometimes no base is required. Now and then cities find themselves the fortunate possessors of natural bases in subgrades of high supporting capacity such as gravel or sand. Where such conditions exist, advantage should be taken of these assets in designing pavement. There are numerous examples of asphalt wearing surfaces laid directly upon native subgrades of this class, which have given complete satisfaction for many years. I have in mind a certain section within the city of Joliet, Ill., where the asphalt surfacing is laid directly upon native gravel subgrade. These pavements have given excellent service for about 20 years.

Asphalt surfaces are a great protection to portland cement concrete slabs. This is perhaps the most outstanding fact developed by such experimental pavements as the Bates and Arlington Experimental Station Roads. Such surfaces protect their rigid bases against breaks following cracks in the concrete. They do not, however, prevent cracks and it is folly to expect no cracks in an asphalt pavement laid on concrete base. Soft asphalt and rich mixtures are no cure for this evil. Rich mix bases are likewise no insurance against cracking; on the contrary, tend to encourage it. Rich mix in bases is only justified in the case of persistently wet subgrades and even in these cases subgrade treatment and drainage nearly always proves to be more economical. It is well known that the richer mixes of concrete are more resistant to disintegration from freezing, hence will usually outlast very lean mixes on very wet subgrades.

One of the recent developments in asphalt paving that is increasing in great strides, is the resurfacing of badly worn and cracked portland cement concrete pavements. For this purpose, hot mix asphalt is proving to be the ideal material.

Another development in connection with concrete bases is machine finishing, leaving only a rough, grainy surface instead of the usual irregular surface. Machine finished base has the advantage of generally smoother asphalt surfaces. It is not advised, however, unless surface mixtures of good stability are laid after careful design. The city of St. Paul, Minn., has pioneered in this development with success.

Wearing Surfaces.—Undoubtedly the two outstanding developments in the field of asphalt paving mixtures are, first, rational mixture design from actual scientific basis instead of the old "cut and try" method and, secondly, the stability or shear test for rating mixtures according to traffic requirements. This test is of great value in investigation of failures, examination of materials, design of mixtures and control during construction.

Two stability tests are in use. One is the Hubbard-Field test which is adapted only to fine mixtures such as sheet asphalt. This test gives an empirical value which represents a combination of functions of the mixture under test. The other is our own test (Chicago Paving Laboratory) which measures the shearing strength of the mixture and is adaptable to all types of mixture regardless of size of aggregate.

Both tests are made at the same temperature, and for fine mixtures, upon cylinders of the same size. In our test, cylinders are increased in diameter and height as the aggregate increases in size. The Hubbard-Field results are not capable of reduction to unit stress, consequently are expressed in total load required to cause failure, hence must always refer to specimen of the same size. The Chicago Paving Laboratory shear test gives values of the basic stress that resists rutting and waving (distortion under traffic loads) and these are expressed in pounds per square inch. A fairly accurate conversion factor is possible between the two tests when applied to fine aggregate mixes such as sheet. Joint work between Messrs. Hubbard and Field and our laboratory shows that Hubbard-Field values are about 75 times ours for identical sheet mixtures.

For several years the need of a physical test for asphalt paving mixtures, capable of measuring resistance to displacement under traffic, has been badly needed. Several years' experience in both laboratory and field leaves no doubt as to the real practical value of these two tests. Since they have been in use, much valuable data has been developed concerning mixture performance. In every case of tests upon old mixtures that have given years of satisfactory service, we have found stabilities in line with those for which we are designing under similar traffic conditions today. For example, mixtures showing shear strength of 50 lb. per square inch, or better, are withstanding the dense, heavy traffic of Michigan Ave. in Chicago, whereas those showing only slightly less than this are rutting under the bus traffic.

Thus it is obvious that mixtures need not be designed in the hope that they will withstand the traffic but they may be so designed that they are certain to do so. The stability, or shear, test has done two important things that alone more than justify it as a practical test; it has exposed the fallacy and danger of attempting to increase stability by means of (a) using harder asphalt cement and (b) laying dry mixtures containing less bitumen than will comfortably fill the voids in the mineral aggregate. Extensive investigations show, first, that a 10 point drop in penetration will mean a gain of only about 5 lb. per square inch shear strength, whereas an increase of 3 per cent in raw filler, say from 15 to 20 per cent in terms of total mix, usually means at least doubling or trebling the shear strength; secondly, both decrease and increase of bitumen beyond a certain optimum amount causes a drastic falling off in stability. Hence by applying a scientifically correct test, it is easily proven that "guessing" and "hoping" for results may lead into dangerous ground—the most commonly used remedy for lack of proper stability not only failed to accomplish hoped for results, but actually harmed the mix.

Correct modern practice calls for two cardinal principles, use as much bitumen as the mixture will carry, and use a soft bitumen consistent with the traffic and actual stability afforded by the mixture. If greater stability is needed, this can readily be accomplished by manipulating the mineral aggregates, especially the filler which is the most important stabilizing factor. It is just plain ignorance to try to design an asphalt mixture around an arbitrary percentage of bitumen.

Thorough Mixing of Aggregates Important.—An important item in mixture preparation that was disclosed by the field investigations of Messrs. Hubbard and Field last summer, is the importance of thorough mixing of the aggregates before the asphalt cement is introduced. Uniformity of mixture depends upon about 30 seconds dry mix with an additional 15 to 30 seconds after adding the asphalt. The stability test proved invaluable in this investigation. The importance of such definite knowledge as this is obvious. Continued mixing at high temperature with the asphalt in thin films on the mineral, tends to harden it materially, in fact, decidedly dangerous hardening occurs of temperatures above a certain minimum, depending upon the asphalt used. Thorough dispersion of mineral once it is coated is not readily obtained, hence the importance of dry mixing with only such additional times as will accomplish thorough coating of mineral since that is all that is necessary. Thus it is seen that arbitrary long mixing periods may not only fail to accomplish the desired results but are actually dangerous.

Use of Machine Finishers.—The most recent development in the art of laying mixtures is the use of machine finishers similar to those used on portland cement concrete pavements. These machines, adapted to hot mix, have proven very successful on highway work, but as yet have not been worked out for city pavements where intersections and changing section introduces a problem. It is to be hoped that some type of me-

chanical finisher will be devised for use on city pavements.

The use of a lute on freshly raked mixture has now become almost universal, likewise the heavy three-wheeled roller for initial compression. All of these improvements not only affect quality of workmanship, but are the source of real economy.

Continued research investigations by leading technologists are not only substantiating many things that have been suspected, but are also bringing to light many new and important facts pertaining to the manufacture and laying of asphalt paving mixtures. The old order of "rule of thumb" procedure must give way to more modern scientifically correct and practically sound methods.

Acknowledgment.—The foregoing paper was presented June 26 before the Michigan Municipal League at Grand Rapids, Mich.

Problems of the Engineering Profession

Due to General Public Misconception of True Professional Status

By D. B. STEINMAN
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THE enginering profession is confronted with a number of problems arising from general public misconception of the true professional status of the engineer.

Improper Method of Engaging Engineering Service.—One of these problems is the persistence of public officials in following improper methods of selecting and engaging professional engineering services.

It is still regrettably common for municipalities or counties, contemplating some public work, to ask engineers, either by advertisement or by letter, to submit competitive bids for furnishing the required engineering services. Such procedure for engaging professional services is fundamentally wrong in principle. It virtually reduces the selection of an engineer to the basis of fee-competition. It hurts the profession by lowering its standards. It harms the public interest by placing a premium on cheapness of service rather than on high standards of professional qualifications.

Let us consider a parallel case. If you were in need of a surgeon to perform a critical operation, requiring specialized knowledge and skill, with perhaps a human life hanging on it, what course would you follow? You certainly would not ask different physicians to submit competitive bids for performing the required operation. You certainly would not go from door to door and engage the doctor who would quote you the lowest fee for the operation. You might find a raw medical graduate who would undertake the case without adequate compensation for the sake of the experience, but you certainly would not entrust it to him. On the contrary, you would seek the most expert suregeon, one of the highest standing and reputation in his field. The question of fee would be a secondary consideration. Where human life is at stake, you want the best professional services, not the cheapest.

Suppose you required legal services on matters involving millions of dollars, what procedure would you follow? Would you engage the cheapest lawyer you could find, or the best you could secure? You certainly would not call for competitive bids for the required legal services. You might secure an inexperienced or second-rate lawyer for a lower fee, but you would gladly pay the difference to retain the best legal counsel where large property interests are at stake.

Selection on Basis of Qualification.—The same principles should apply even more forcibly in the selection of professional engineers. Public officials seeking consulting engineers to design and supervise the construction of large public projects should regard it as a public trust reposed in them to select the most competent engineers on the basis of qualifications and experience, and not on a basis of fee competition. To the physician you entrust human life. To the lawyer you entrust property interests. To the engineer you entrust both: Upon his conscientious expertness and skill, the safety of both life and property are dependent.

Each profession has its standards of fees, based on the investment of training and experience and the cost of providing proper and adequate services. The engineering specialist has the same high investment of training and experience as the highest ranking physicians and lawyers. If engineers are induced to cut their standard fees by the pernicious custom of subjecting them to fee-competition, they cannot give the full measure of generous service and performance upon which the standard fees are based. The difference in fee is a mere trifle in comparison with the much larger savings which may be effected through the skill, knowledge, and efficiency of the expert professional engineer.

The custom of asking engineers to submit competitive bids for professional services probably arises from a confusion in the minds of public officials who do not distinguish between engineering and construction. The one is professional, the other is commercial. To the extent that construction work may be minutely and definitely specified, it is appropriate to select contractors by competitive bidding. But the planning, designing and specifying of the construction work represent professional services, involving the human equation, and themselves incapable of definite specifications. Two different engineers on like engagements will not give the same services, in kind or quantity. Professional work, whether law, medicine, or engineering, cannot properly be reduced to a basis of competitive fees.

The correct procedure for public officials, who wish to conserve the best interests of the communities they represent, is to ascertain through informed and impartial sources who are the best qualified engineers to handle the contemplated project. For this purpose, the National engineering organizations may be consulted. After the engineer or engineering firm is selected on the basis of such investigation or recommendations, then the amount of the fee can be arranged by mutual agreement or on the basis of published professional standards. Only by such procedure will the best interests of the public be served.

Free Engineering Service.—Another problem faced by professional engineers is the expectation or demand for free engineering services before a project is authorized or before an engineer is selected. This practice may take the form of asking engineers to make preliminary studies, surveys, estimates, and reports on a proposed undertaking, without compensation, but with the possibility of a professional engagement as a bait. Another form of this practice is the invitation addressed by public officials to engineers to submit free designs and estimates for a given project as a basis for awarding the professional engagement. Such practices are unfair, unsound, and contrary to public policy. It is an economic waste to multiply services on a given project. To base the selection of an engineer upon the comparison of uncompensated preliminary estimates places a premium upon the skimpiest design or the most elastic conscience. Such practice is conducive to subsequent disappointment or failure. Free service can hardly be expected to offer the requisite degree of thoroughness and reliability. Some one has to pay the freight. Professional men may be expected to give free services in charitable cases. But public communities and corporations can hardly be classed as charity cases. The laborer is worthy of his hire. If the services are worth anything, the engineer should not be asked to furnish them without compensation.

Instead of asking different engineers to gamble their time and money on making competitive designs and estimates, the public body should select an eminently qualified engineer in whom it has confidence, and pay him to make the alternative designs and studies of cost as a basis for any decisions and selections.

Public Fails to Give Engineer Credit.—A third problem confronting the engineering profession is a failure of the public to recognize the full scope of the qualifications and training of the engineer. On public boards, municipal councils, and planning commissions, the engineer is still generally conspicuous

by his absence. The public fails to realize that the modern engineer does not limit his work to surveying and drafting, or the computation of stresses and strains. By training and experience, and by force of the diversity and complexity of the problems he has to handle, the modern professional engineer is an expert on ecoonmics, financing, promotion, organization, and management. The modern engineer has to conceive large projects in their broadest aspects and in their most far-reaching ramifications. He has to investigate and demonstrate their economic soundness and financial feasibility. He has to organize, direct, and supervise the work of armies of men. He has to conceive, plan, and execute projects of largest magnitude. He has to exercise vision, resourcefulness, judgment and versatility beyond the requirements of any other profession.

With these qualifications, in addition to his knowledge and understanding of public improvements from the professional viewpoint, the engineer should be found in all important executive and administrative positions. The public cannot afford to have the engineer missing from public boards, councils and commissions.

Our profession has always pointed with pride to the early engineering career of Washington, and to the record of Lincoln as a land-surveyor. For the failure to elect more engineers to distinguished public office, we found gratifying consolation in the fact that two representatives of our profession had been Presidents of the United States, and that these two had been the greatest Presidents in the Nation's history. Now we can add a third name to the list, for in Hoover we have an exemplification of all that we mean today by the name engineer—a planner, an executive, an administrator. With the names of Washington, Lincoln and Hoover to inspire us, we may look forward to the day when engineers will be recognized and sought for all of the highest positions of leadership and trust throughout the land.

Acknowledgment.—The foregoing is an address delivered March 30 in the A.A.E. radio program from Station WNYC, New York City.

Latest Methods of Road Finance, Construction, and Administration Treated in New Booklet

A timely publication involving an extensive study on the subject, "Highway Construction, Administration, and Finance," is announced by the Highway Education Board, Architects Bldg., Washington, D. C.

It deals with the planning of a national highway system, with the various types of road suitable for differing traffic conditions, and with methods of financing such highway building. The studies are by E. W. James, Chief of the Division of Design, United States Bureau of Public Roads, and now on leave in Colombia assisting that South American government in organizing a road-building program. The booklet is printed in Spanish, Portuguese, and English.

"Poor roads," says Thomas H. MacDonald, chief of the United States Bureau of Public Roads, in an introduction, "cost more than do adequately serviceable roads. Roads built with honest administration and skilled technique have an earning capacity far beyond their cost. So the serviceable public highway has every right to be listed as an asset and not as an expense. It has already been well demonstrated that the highway can earn its upkeep, plus a very high profit on the investment.

"Road tolls collected in the form of motor vehicle license fees and gas taxes in the United States amount to a very large percentage of the annual highway bill, without excessive cost to the individual user. The very fact of relatively low taxes has encouraged the enormous use of the roads by so large a number of the public. This accounts for the high income from the roads in actual financial returns. It proves the value of good highways."

Recognizing that the financial problem involved in the highway program is in all countries "the fundamental and difficult one to solve," Mr. James points out that, in order to keep expenditures to a minimum, three things must be attempted:

1. To select the right roads to be improved;
2. To determine the correct types to build at any time; and
3. To build progressively, but so that all work done may be salvaged in future work.

The best method, he asserts, is "deliberately to plan a national highway system." It matters not, he adds, that pioneer roads and trails have developed, that some roads already have been improved, that cities have grown and the rural districts have been put under cultivation. Such study, he says, may disclose errors of the past and may lead to a change in location and priority of construction for many miles of highways, but if it does it saves money.

"Studies of highway systems made in the United States during the past three years," says Mr. James, "clearly demonstrate the value of such work even at a late date. But obviously the earlier in the highway history of a country such studies are made the greater good will flow from them."

The general character and condition of economic development, as revealed in data based on population, agricultural production in tonnage for general crops and in cost for special crops, such as dairy products delivered directly for consumption, and manufactured products by cost, must be surveyed, it is stated, in approaching a national or state highway plan. Other factors which must be considered include topography; existing traffic on the roads and the classification of this traffic; and the probable adequate mileage of roads in the system as a whole and in the several political or economic subdivisions thereof.

Emphasis is laid in the Highway Education Board's report on the importance of the progressive method of road building which, it is asserted, is "the only way possible to give service within any reasonable period to a state or nation which yet has most of its pioneer roads to improve."

As to financing it is declared that "roads should be built only to the extent and of such types as will pay for themselves." Every piece of construction, it is asserted, should be planned with an eye to the future and to the possibility, indeed to the probability, that a betterment of type will be required. Any highway expenditure to be justified must be earned by the road in the form of cheaper transportation, says the report, which argues that highways are fundamental requirements in a healthy, progressive, prosperous, and ambitious nation.

Fast Roads Proposed for Netherlands

The Nederlandsche Vereeniging voor Auto-Snelwegen (Netherland Association for Fast Motor Roads) is conducting an active campaign in the country for the building of through roads to be devoted exclusively to motor traffic, according to a report from Assistant Commercial Attache Paul S. Quinn, The Hague, released by the Bureau of Foreign and Domestic Commerce. Their plan is to build one road from Amsterdam, the capital and country's largest city, to Rotterdam and on the southern border leading into Belgium, another from The Hague through Utrecht to the eastern border leading into Germany, and to connect Amsterdam to the east-bound highway by a special connecting roadway between that city and Utrecht. According to present estimates the cost of this entire road plan would be around f. 200,000,000 ($80,400,000) and it is indicated that there is sufficient banking support to execute the scheme providing the Government will undertake to guarantee interest return on the investment.

The organization devoting itself to promotion of the proposed motor road plan is made up of a number of people interested in road problems including a representative from each Algemeene Nederlandsche Vielrijdersbend and Koninklijke Nederlandsche Automobielclub, two important associations devoted to automobile, traffic and roadway developments.

New Developments in Safeguarding and Eliminating Cross Connections

A Summary of New Developments in New York State

By C. A. HOLMQUIST and EARL DEVENDORF
Director and Associate Director, Division of Sanitation, New York State Department of Health

THE subject of cross-connections between public water supply systems and auxiliary industrial and fire supply systems from various polluted sources, has been much discussed and written about by leading water works and public health authorities throughout the past decade. Not alone in New York State but throughout the United States, there have been numerous occurrences of waterborne outbreaks of disease, attributed to polluted water entering the public water supply systems through various types of cross-connections.

The New York Regulations of 1925.—The Public Health Council of the State of New York after a prolonged and deliberate study of the problem of cross-connections between potable and non-potable water supplies, enacted, in November, 1925, the following regulations, known as Regulations 15-a and 15-b of Chapter VII of the Sanitary Code, requiring by July 1, 1928, the elimination of such cross-connections in New York state:

"Regulation 15-a. Certain cross-connections between water supplies not permitted. No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall permit after July 1, 1926, any physical connection between the distribution system of such supply and that of any other water supply, unless such other water supply is regularly examined as to its quality by those in charge of the potable water supply to which the connection is made and is also found to be potable. This prohibition shall apply to all water distribution systems either inside or outside of any building or buildings.

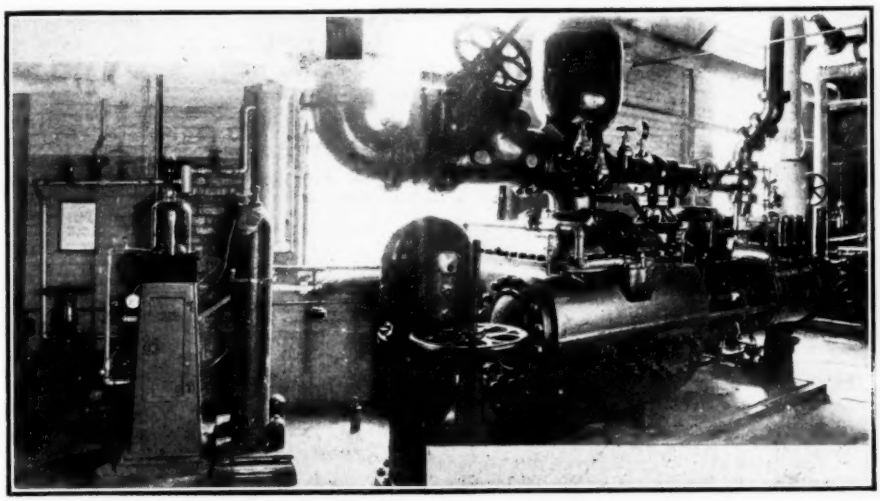
Provided, that, where such physical connections now include two gate valves with indicator posts, two check valves of the Special Factory Mutual Fire Insurance design or equivalent with drip cocks and gauges for testing, all located in a vault of water-tight construction accessible for ready inspection, the date of discontinuance may be extended until July 1, 1928.

Regulation 15-b. Permissible arrangements where dual supplies are used. If a potable water supply is used as an auxiliary supply delivered to an elevated tank or to a suction tank, which tank is also supplied with water from a source with which cross-connections are not permitted by Regulation 15-a, such tank shall be open to atmospheric pressure and the potable water supply shall be discharged at an elevation above the high water line of the tank."

Subsequent to the enactment of these regulations, protests of representatives of certain industries in the state were made to the Public Health Council. Following these protests, the council conferred with manufacturers, health officials, water supply officials, sanitary engineers, fire protection engineers and insurance organizations and held numerous hearings in various parts of the state, as a result of which the council became convinced that the severance of connections between potable and polluted water was demanded for the protection of the public health.

In view of the various hearings held and the time consumed, a great many industries had delayed taking active steps to make the necessary construction changes to conform with the regulations of the code. Accordingly, requests were received from a considerable number of industries, requesting extensions of time, due to delays, many of which were unavoidable, in having the necessary changes made to comply with the code.

Special Fire Pump Chlorination.—Moreover, in May and June of 1926, a new development in chlorination apparatus was brought to our attention which, it was thought, possibly might permit certain plants to chlorinate their auxiliary supplies and render them potable from a public health standpoint. Tests of this so-called special fire pump chlorinator equipment were made covering a period of some six weeks, as a result of which it was determined that the apparatus with proper supervision would be capable of effectively chlorinating an auxiliary supply under intermittent operation of fire pumps and thus rendering such auxiliary supply potable, provided it was only moderately polluted.



A Fire Pump Chlorination Installation

Requirements for Installation.—Such installations must, however, meet the following requirements:

1. The water supply must not be so grossly polluted that it cannot be effectively chlorinated.
2. The fire pump must either take suction from an open well or sump or there must be a municipal water supply available having a pressure at least three times as great as the pressure on the suction of the pump.
3. The chlorination equipment must be of a type approved by this department and so equipped as to continuously waste a small amount of chlorine solution and provided with solenoid or steam operated valves so regulated that immediately upon the starting of the pump it will apply chlorine at a rate of not less than 20 lb. of chlorine per million gallons of water pumped.
4. Platform scales must be provided

for checking the loss of weight of chlorine.

5. Plans of the installation, together with report and sufficient data to pass upon it, must be submitted for approval to both the local water authorities and to the State Department of Health.

6. Reports of the results of daily orthotolidine tests of the chlorine solution wasted and the amount of chlorine wasted or used per day must be submitted at least monthly to the municipal water supply authorities.

7. Chlorinators on all auxiliary industrial or fire supplies must be inspected regularly and at frequent intervals by local water supply authorities.

8. The cross-connection between a potable municipal supply and a chlorinated auxiliary industrial or fire supply must be equipped with double check valves of the "all-bronze" type placed in an accessible chamber and properly equipped for testing and inspection. Such check valves must be inspected and tested at least monthly and taken apart, thoroughly cleaned and any worn parts replaced at least yearly.

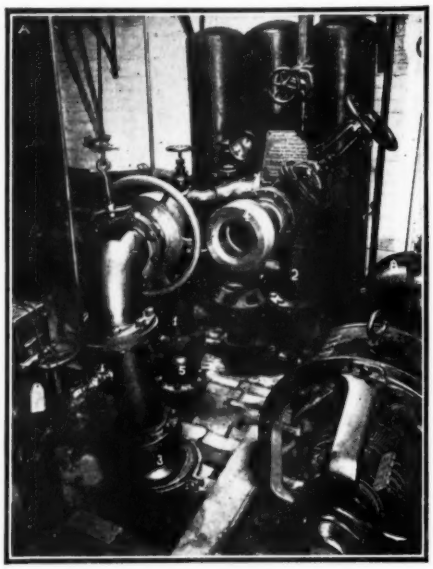
9. Discharge valves on the fire pumps must be closed whenever the pumps are turned over for testing.

10. Any approval by the municipal and water supply authorities or this department will be given only on condition that the chlorination apparatus is satisfactorily installed, operated and maintained at all times.

Results of Plant Changes.—To date there have been some 60 fire pump chlorinator installations authorized among 55 of the industrial plants of the state. A recent report of one of the insurance associations on the results of plant changes made to comply with the provisions of the code, show that out of a total of some 147 plants listed, the total estimated cost of changes necessary to comply with the Sanitary Code was about $350,000. These changes included installation of all-bronze check valves in pits, erection of gravity and suction tanks and changes in yard piping. It was estimated that the cost of heating gravity and suction tanks would be from $250 to $400 annually. It is further estimated that the fire pump chlorinators would use up approximately $110 worth of water and chlorine per year, besides the necessary supervision, making a total annual maintenance charge for the chlorinator of say $200.

There have been in some special cases, considerable expenditures necessary to eliminate satisfactorily cross-connections and at the same time provide industries with adequate fire protection. In one of these instances, the industry spent over $25,000 in placing new mains to carry the polluted water supply and thus eliminate the cross-connection with the public water supply.

Cross-Connections Eliminated Wherever Possible.—It must be borne in mind, however, that in our program of safeguarding cross-connections, it has been our endeavor to eliminate the cross-connections wherever possible. Moreover, the quality of the water supply to be treated is carefully considered and in six instances, applications for permits for the installation of a fire pump chlorinator were denied, because it was found the sources of the fire pump supplies were too polluted to permit of chlorination being relied upon. Furthermore, in all instances where fire pump chlorinators have been installed, it has been required that double check valves of the all-bronze type be installed in place of the old iron body type.



Front View Showing Swing Joint Arrangement Eliminating Cross-Connection Between City or Potable Water Supply and Emergency Non-Potable Fire Supply

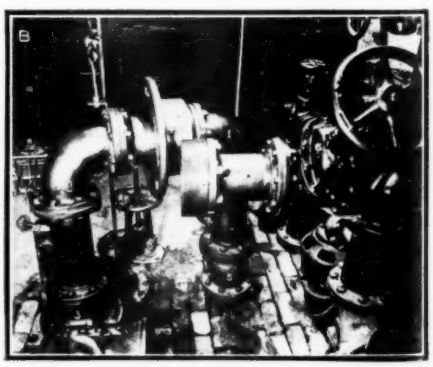
Throughout the past two or three years, many conferences and investigations have been made with public water supply authorities and representatives of industries, with particular reference to the elimination of cross-connections. In the majority of these instances some satisfactory and reasonable plan or program could usually be found for eliminating the cross-connection. In all instances, in which permits have been granted for the installation of fire pump chlorinators, the need for careful and constant supervision of the apparatus has been emphasized. In fact, it has been pointed out that should the fire pump chlorinator be neglected, the permit would be revoked and it would be required that the industry eliminate the cross-connection.

Chlorinators Operated Satisfactorily.—The earlier fire pump chlorinator installations have been in service at the time of this writing for some six months. The majority of them have been in operation at least four months. Monthly reports on the daily results of tests and observations of the operation of the chlorinators received by the department indicate that the fire pump chlorinators have, with minor exceptions, operated satisfactorily. Inasmuch as this has been an entirely new departure, it was to be expected that there might develop some features which might not be entirely satisfactory. There have been but few instances, however, where such conditions have occurred and where they have, it has been possible to determine the cause and correct the same. Although six months would be somewhat too short a time to predict with certainty the future of the fire pump chlorinator, it would appear that, given proper and careful daily supervision and maintenance, the equipment is capable of satisfactorily chlorinating an auxiliary supply under intermittent operation and render such auxiliary supply potable, provided it is only moderately polluted.

The Swing Joint Arrangement.—There has also been developed a so-called swing joint arrangement which, so far as is known, has not hitherto been employed, at least on a commercial plant size scale, to make available either one of two water supplies. By this type of arrangement, the city supply, which is normally used, can be shut off and the industrial distribution pipe line changed by means of a swivel joint to connect with the fire pump supply which, thereafter, can be placed in use. Although such a system has been approved by the State Health Department in a few instances under certain conditions, the insurance authorities have not looked entirely with favor on this type of connection, except under very favorable situations, inasmuch as it is open to the following possible objections:

1. There is a period of time during the making of the change when no water supply pressure is available.

2. Instead of having two sources of supply available simultaneously for fire fighting purposes, as is the case where both the city and the fire pump



Side View of Swing Joint Arrangement Eliminating Cross-Connection Between City or Potable Water Supply and Emergency Non-Potable Fire Supply

supplies are connected through suitably arranged check valves, there can be only one source of supply used at a time. So far as we know there have been only about a half dozen of such installations throughout the state.

Cross-Connections on Water Service Lines.—In addition to these cross-connections on fire supply lines and mill service supply lines, cross-connections have been found on water service lines for priming pumps, for boiler feed, for cooling purposes, etc., usually made for use in emergency to obviate shutting down some particular piece of machinery and frequently made for convenience or through ignorance. When such cross-connections have been discovered and the matter has been taken up both with the authorities in charge of the water supply and the owner of the property or the industry, prompt steps have been taken in all instances to eliminate these cross-connections which may oftentimes be more dangerous than the well regulated and supervised larger type of cross-connections.

Although the Sanitary Code places the responsibility for eliminating cross-connections on the local water supply authorities, the department has been called upon for advice and assistance by the local water supply authorities as the problem of eliminating the cross-connections, particularly in the case of the larger industries, involves special engineering questions. The importance of making careful inspections of piping systems at industrial plants to discover any possible cross-connections has been forcibly brought to our attention and we have emphasized to the local authorities the need for such inspections. It would appear that the painting of pipe lines in colors or with colored bands will undoubtedly greatly reduce the hazard from cross-connections made through ignorance or carelessness. Such standards are already in use in power house practice.

Careful Study of Individual Conditions Necessary.—Although conditions are found to be somewhat similar in numerous instances, there are hardly any two plants having the same hydraulic conditions and it has been found necessary to make a careful study of the conditions at each individual plant in order to determine the most satisfactory and economical method of eliminating the cross-connection. Moreover, in all cases the industries and manufacturing establishments have been advised to take the matter up with their fire insurance authorities, in order that any improvements or changes in the piping system will be made with the approval of the fire authorities.

I would be remiss, indeed, in this brief summary of the action taken to eliminate cross-connections in New York State, if acknowledgment were not made of the splendid cooperation and assistance rendered by the representatives of industries and insurance authorities. Indeed, without their cooperation, the progress already made in this very important and large undertaking could hardly have been accomplished within so short a time.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 46th Annual Convention of the American Water Works Association.

Chlorination of Pipe Lines Under Construction

By JOHN R. McCLINTOCK
Construction Foreman, Indianapolis Water Co., Indianapolis, Ind.

The company for which I work has for some time required its construction foreman to see that the pipe is not only well "swabbed" and made thoroughly free of any loose matter before placing it in the trench, but also that it is well chlorinated after being placed therein.

The process by which this is done is very simple and does not require a great amount of time. It is as follows:

Make the "first end" connection and as first length of new pipe is laid or connected to existing main, one can or container of hypochlorite of lime should be shaken into that length of pipe and at each interval of eight lengths of pipe another container should be emptied into that length of pipe and so on to the completion of line.

However, when a hydrant or a valve also is set in the main the valve may be closed and the line filled slowly from point of first connection until first appearance of water at hydrant, when the hydrant should be closed and the water allowed to stand for 30 minutes and then flushed thoroughly until no odor of chlorine can be detected in the waste water.

This facilitates the work of backfilling and flushing trenches by getting part of the new line into service. Water used to flush out pipes need not be wasted, for where economy in amount of water used is an item, it can be profitably used to flush or settle back-filled ditches.

On first thought it appears proper to make an allowance for the relative capacity of different sized mains, but we believe it more likely to be handled successfully if construction foremen are instructed to place a given quantity at the head of each 100 ft. of pipe laid and flush it out thoroughly when job is complete up to an end hydrant.

The reason for this is that for 36-in. pipe at a dose of 100 lb. per million gallons, the quantity required is 1 lb. per 100 ft. In either case it is necessary to flush the line until no odor of chlorine is detected at discharge hydrants. The removal of chlorine from the line to this degree will insure thorough cleaning by displacement alone in addition to the sterilizing effect.

While the pipe line is incomplete all openings should at all times be kept plugged, which will prevent circulation of air and thus preserve the strength of chlorine until its final removal from the pipe. After completion of the pipe line care should be taken to see that, in the removal of this treatment, none should be allowed to enter any existing line.

To get the best results it has been our method to open a fire hydrant at the furthest end of line, then to open a valve at point of beginning, letting water flow through the pipe slowly until it appears at the hydrant, shut it off for period of about thirty minutes, then open up and blow out thoroughly until the water shows clear.

At this point, reverse the operation by closing the valve and hydrant first opened and then open the valve and hydrants at opposite end of line and blow out until water is clear and free of odor of chlorine, after which open all hydrants on the line, then proceed to turn on all intersecting lines beginning at end of line from which water is flowing, still keeping hydrants open to carry out any chlorine that may have lodged in ends of branch lines and lastly open up the valve on furthest end of line.

In case there is no hydant on the end of the pipe line thus treated, it is necessary to shut off the adjoining section, opening up several hydrants first. Then open valve from new section, letting water blow out as speedily as possible that the line may be cleared of all effects of treatment before being taken into service lines of consumers.

This instruction to disinfect newly laid pipe lines should in no way, however, lead construction foremen to reduce the degree of care they have previously used in cleaning and flushing such lines.

As a matter of general information the chlorine container stocked by commercial dealers holds 12 ounces. A case of these contains fifty and costs $5.60.

In conclusion, let me emphasize the point that water used in flushing out treatment need not be all waste as it can be used to flush or settle backfilled ditches.

In case of a "dead end" where it is impossible to blow out the line, the only thing to do is to use extreme care that the pipe used therein be well "swabbed out" before being laid.

Acknowledgment.—The foregoing is an abstract of a paper presented before the Indiana Section of the American Water Works Association.

Airport Design and Construction

Fundamentals and General Details

By PHILIP R. LOVE
Of Love-Sultan, Inc., St. Louis, Mo.

PROBABLY no other phase of aeronautical development offers as fertile a field for the exercise of enthusiastic ignorance as does the selection and preparation of airports.

Aviation is neither a sporting proposition nor a theatrical enterprise, but a definitely and well-established transportation utility or agency, the widespread acceptance and adoption of which is as necessary today for a town or area anxious for continued growth as was similar acceptance and adoption of the railroads three-quarters of a century ago. Even the most casual observation compels recognition of the fact that the biggest and best cities are those with the best transportation facilities, which connect with the rest of the country and the world. Aviation is just one more transportation agency, and the city of tomorrow will grow with it or stagnate without it.

Most cities appear to realize this more or less clearly and are attempting to establish terminals or ports for the handling of this new form of transportation; but the whole development is so new, and so few persons have a comprehensive grasp of the elements and the need of ports, that much loud and vigorous effort is being misapplied.

Probably as common an error as any is the tendency to under-estimate the cost of adequate facilities. A good port is an investment in future growth and prosperity, and, in common with other things mundane, can be expected to pay return on the amount of the investment, and no more.

This error is most generally reflected in the unwise procurement of a port site on the basis of the price of the land. If a railroad desires a station site, a chain-store group a site for one of its stores, a theatre circuit site for a new playhouse, or any other business—except aviation—a site for the conduct of its activities, it considers the whole question from the viewpoint of attracting patronage rather than from the viewpoint of minimum cost for a certain-sized tract of land.

As long as flying is new in a community and offers allurement as a spectacle, people will flock to a port as to any other big free show; but as soon as it settles down—and it doesn't take long—to the routine arrival and departure of passenger, mail, and express planes flying on schedule, it must offer convenience to its potential clientele—or there will be none. The man or woman who goes into raptures over the fascination or the beauty of aerial transportation is frankly open to the suspicion of exaggerating matters, for hour after hour of flying over country which one has seen time and again is as monotonous as any other type of travel. As against this it is speedier, cleaner, and fully as comfortable as any other method, but this is soon outweighed if one has to travel long distances over indifferent roads to and from the ports at each end of the air journey.

Site Should Be Easily Accessible.—Thus it is that due consideration should be given to quick and comfortable access to town if full value is to be received from the port investment, and the search for a site should begin as close to the downtown district as possible. Nor should the fact that property happens to be occupied and used for other purposes cause it to be rejected for that reason alone, for the cost of its acquisition with the resultant scrapping of some present investment may be wholly justified by its comparative convenience of location.

Of course, it goes without saying that the fundamental requirement in the selection of any port is that of safety, for all other advantages combined cannot outweigh the disadvantage of immediate or adjacent hazards. As to what these hazards are, if one does not know and is charged with the selection of a port he had better not try to pick a site, for too many a poor devil has come crashing down in a flaming heap of shattered spars and shredded fabric on or near ports cluttered up with bordering trees, high stacks, railroad yards, high-tension lines, crowded buildings, and the like. Enough to fill many books could be written on this one phase of selection, and one could read them all and still not know the half of it. The answer is that if one has not flown in and out of ports with good ships and cranky ships, with good motors and those not so good, in good sunny weather, and in thick and blustery twilight, he should find some one who has, and then get his help.

Important Points to Be Considered in Selecting an Airport Site.—However, with a field properly selected as to availability to town and freedom from immediate and adjacent hazards, one is still a long way from a sane decision until many other points or features have been weighed. Some of the principal ones to be considered are:

Avoid an area habitually clouded by smoke or frequent local fogs. Specifically, if a town is an industrial center with soft coal as the principal fuel, or one where residence heating is done with the same material, it will be found that the side toward which the prevailing winds blow will have the poorest visibility and should be avoided. Again, a river, lake, or bay on one side of the town may occasion frequent low-lying morning fogs that will completely blanket a field or port located there, and should therefore be avoided.

Drainage.—Another thing to consider is drainage. If the area overflows with spring-flood backwater, keep away from it. Up to within the last two or three years great stress was laid on the selection of sites as "level as a floor." Today such sites are taken only as a last resort, for they require a large sum for adequate drainage—if they can be drained at all. Basically, any field should have sufficient slope at all points to preclude the pounding of water. The ideal field in this respect is one rising gently from the mid-point in the direction of the prevailing winds. This is advantageous from an operating and lighting standpoint as well as for drainage, for it offers descending grades from the rim for the acceleration of ships taking off; ascending grades for a ship landing in midfield; and better illumination of the far side of the field from floodlights placed along one side. Contrary to this a field with a ridge in the middle should be avoided in that the grades are wrong for either landing or taking off, the light from a unit along one side is cut off at midfield, and too pronounced a ridge introduces the possible hazard of collision of two planes on the ground and traveling in opposite directions.

Next, the soil should be observed or studied. A sandy loam with a good top soil is best, for it permits a good stand of turf and allows the absorption of rain, which serves to keep the field from getting muddy and holds the moisture necessary for good turf.

With all of these things watched, there will probably still be need for more or less subsoil drainage. Depending on the character of the soil and the turf, a goodly portion of the water falling in a hard rain can be allowed to flow off over the surface, but nearly every field will have some areas requiring porous drain lines of some sort. Clay or concrete pipe laid with open joints, preferably in rock-filled trenches, is quite commonly used for this purpose, but should be of good quality and laid deep enough in the ground to withstand crushing under the impact of landing planes. In addition to this the manu-

facturers of corruglated-iron pipe have developed a perforated pipe for this service. One thing which should be avoided is cast-iron or steel manhole covers or inlet gratings flush with a turf field, for the softening of the adjacent area will make sudden contact with these structures dangerous.

Another factor in connection with drainage is frost, particularly when it is coming out of the ground in the spring. This is apt to create a condition where the subsoil and subdrains remain frozen after the topsoil has become a mire. This further dictates the selection of a sloping area.

Grading and Shaping Field.—With the field selected and disposal made of the drainage problem, the next step is grading and shaping. Usually there will be some portions requiring more or less grading. In general all ridges or hollows should be lowered or filled until the gradient at no point exceeds 2 per cent. In addition to this some additional grading may be required to eliminate shadows when the field is lighted from the margin. The rows in cultivated fields generally present a formidable appearance, but are not very difficult or expensive to eliminate if attacked with the proper equipment. Disk harrows and a heavy steel drag usually work the best on these—both tractor-drawn. The best disks are the "double" type with two gangs in tandem, one deflected in and one out from the center. The first time over these should be drawn parallel with the rows, and then at right angles. The best drag which has been developed for the next step is one made of structural-steel channels laid at right angles to the direction of the travel and overlapping one another like shiplap, the slope being upward to the front with the legs of the channels standing up and the front web of each channel bearing on the rear leg of the preceding member. These are fastened to side runners—also channels—with angle clips and bolts. The whole is dragged behind the biggest caterpillar tractor available, preferably the largest made, which will handle a drag about 16 ft. across and 12 ft. long, and which will put the field in excellent condition where only a small amount of work with a road machine will be required for completion.

If there is already a stand of tough but rough or irregular turf on the field or portions of it, it may be necessary to turn this over with a plow before harrowing and dragging; while if a field of corn is attacked late in the season after the roots are fully developed, the corn should be pulled instead of cut to avoid the trouble occasioned by these roots and stubbles rolling up on the surface.

If the field was originally covered with Bermuda or other equally tenacious grasses they will generally come up through and resod the area. If not, either sodding or seeding will be required. Sodding the whole area is usually out of the question, but "spot" sodding with plants on about 3-ft. intervals with Bermuda or other running grasses will give a fair stand at the end of a full season, particularly if seed is added. If the field is finished in the fall, winter wheat, oats, or rye makes a good winter crop and mother crop for grass seed planted in the spring, particularly if 200 lb. or so of sulphate of ammonia or other good fertilizer is broadcast with the seed in the spring.

Location of Buildings.—The location of buildings on the port calls for the observation of a few "don'ts." Don't locate them where they must be crossed by planes, either landing or taking off, on the best approaches. Don't locate them where the prevailing winds will keep them full of dust from the field. Don't locate them in a low place where heavy rains will wash through them across the field, or so low that floor drains or plumbing fixtures cannot be given good outlets.

In general, locate them where good access to good roads leading from the port is economically available; locate them on some established and orderly plan with their faces or ends lying along a definite line instead of setting at various angles. If possible, leave sufficient room between the buildings and the edge of the port to permit of a proper landscape treatment, for the mere fact that an area is devoted to airport purposes does not mean that it must be ugly to be useful. Give thought in the grouping of the buildings to future use and to comfort—for instance, do not put a service or shop building where motors will roar on test night and day right adjacent to the administration building, pilots' quarters, or other places where reasonable cleanliness and quiet are desired. In other words, make the grouping along studied lines instead of allowing any and every one to put what they please where they please.

As to the detail and the character of the buildings themselves, "Costly thy habit as thy purse can buy, for the habit oft proclaims the man." A heterogeneous bunch of overgrown corrugated-iron shanties sprawling at will along the edge of the port will promptly discourage any substantial and attractive future development, and lower the value of all adjacent property as well.

In their eagerness to "get on the air map" many cities have done this very thing, excusing it with the vague apology that these are but temporary facilities, and that other and better ones will be provided "when the industry gets on a more stable basis." However, the first few buildings erected at a port generally established the character of the permanent development.

As to building materials, let these be as fire-resistant as possible, and design the buildings to permit the installation of sprinkler systems at some later date if not when they are erected. Long spans and clear areas are necessary, so the best general type of construction is steel columns and trusses and light-weight roof structures such as 2-in. tongue-and-groove wood sheathing on 7-ft. or 8-ft. spans, surmounted with a good grade of built-up roofing. Many manufacturers are urging the use of crimped steel sheets covered with fiber insulation, in lieu of the wood sheathing, but the cost is higher and there is honest question as to whether or not the thin sheets such as they urge will withstand fire and corrosion any better than wood.

Important Features of Airport-Building Design.—The structural elements of the buildings must be carefully studied and the members must be appreciably heavier than those in similar buildings located "in town" where adjacent buildings shut off much of the force of the winds, for the very nature and location of airport buildings subject them to winds with a full sweep of half a mile or more.

Another fundamental of airport-building design is to provide plenty of natural light. This means as much window area as can be obtained without sacrifice of stability or architectural appearance. Steel sash and lots of it is the best answer to this demand, and particular attention should be paid to proper design of mullions and other structural features so that they will withstand wind velocities and pressures. Also wire glass should be used for this same reason, for a properly and economically designed building will deflect and react more or less under wind action, and thin, non-reinforced glass has a tendency to break under such conditions.

Doors deserve much consideration. With the increase in wing spreads, doorways are becoming both wider and higher. Here again the wind is a real factor. On some hangars which we have built recently the doors are 120 ft. wide and 22 ft. high. To withstand the wind these doors must have the structural ability to carry a heavy horizontal load. This means heavy stiles and rails and substantial panels, with a correspondingly heavy weight per lineal foot of door. The most generally accepted practice is to make these doors of steel, and to slide them along floor tracks on well-designed wheels or rollers. Several manufacturers have designed such wheel or roller units that permit the doors to operate around corners, and this general practice is recommended.

The color of buildings should be a light shade of buff or tan—or even white—to insure the highest possible visibility both day and night.

At first, airport buildings were hard to treat architecturally, but a definite type of characteristic "airport" design is coming to the fore rapidly, and we are learning that sympathetic treatment of mass and color will give buildings a really pleasing appearance

without exorbitant cost, and the whole industry has ascended to a plane where this is not only justified but demanded. Care should be taken, however, not to lean over backward in this respect in the desire to outdo the rest of the country, for after all the flying industry is like any other industry in that it must show a profit or else fall of its own weight.

The buildings required at a port vary with its location and use, but certain specifications governing restaurant facilities, sleeping quarters, toilet facilities, waiting rooms, etc., must be observed if the port is to receive a favorable rating from the Department of Commerce. Copies of these specifications, or requirements, may be obtained from the department for the asking, so space will not be taken here to repeat them. These specifications also set forth the sizes and shapes needed on the fields themselves for the obtainment of the various ratings, and should be consulted before any other steps tending toward port selection and development are taken.

Lighting for Night Flying.—With field and buildings both prepared, there is still another requirement before a field can be given its best rating. This is lighting for night flying, which latter is increasing very rapidly, and for which provision must be made at all good ports. The basic requirements for lighting are for boundary lights at intervals not exceeding 300 ft. completely around the field; a beacon light of certain characteristics to guide the flier to the field; a ceiling projector to determine the height above ground of the bottom of the cloud ceiling in heavy weather; red lights atop all adjacent buildings, pole lines, tall trees, or other obstacles around the port; approach lights to indicate runways or the best landing strips; an illuminated wind cone or other indicator showing wind direction; and a floodlight, or floodlights, to illuminate the landing area to a certain density. In addition to this, part or all of the buildings around the port should have their sides illuminated in their entirety and their roofs wholly illuminated or with illuminated signs thereon. Definite requirements for all of this lighting are set forth in the specifications already mentioned, and these must be followed if a creditable port is to be provided.

Immediate and Adjacent Hazards.—The problem of immediate and adjacent hazards varies with the use or uses of a port. Transport planes with heavy passenger loads both come in and go out on long, flat glides, so that the approaches to a transport field should be free from any high obstructions for an appreciable distance to obviate the necessity of either coming in high or having to pull a plane into a steep climb in taking off. An air-mail or taxi field used solely or primarily for light, fast planes, and skilled pilots does not require so much attention given to approaches, for planes in this service can come in and go out at comparatively steep angles. The third type of flying is school work, and more attention must be given to the approaches of a school field than to either of the other two, for undershooting, overshooting, or stalling on too steep a climb on take-off sometimes occasions unexpected forced landings beyond the limits of a field. Unquestionably, with the increase of all types of flying we shall soon face the need of segregating the three types, particularly on account of the hazards of school flying where the green pilot has a whole day's work mapped out for him in the handling of his own craft and cannot be trusted not to cut across the bows of a heavily loaded transport plane floating in to land. If the selection of a port is for one of these specific types of flying, the approaches and general location may be gaged accordingly; but if the field is for all types of flying activities during its first months or years, it should be laid out to the most exacting requirements.

Probable Cost of an Airport.—A port wherein intelligent attention and treatment have been given to these foregoing items will cost probably at least a quarter of a million dollars for an A-1 rating, or one on an unobstructed and unpenalized area 2,500 ft. square with adequate buildings and lighting. This price tag, however, cannot be applied without study of the particular problem involved, for real-estate costs, grading, drainage, and all of the other items will vary manyfold in different locations. For instance, one field on the route of one of the transcontinental transport lines is located within a few minutes' ride of the heart of one of the largest cities of the mid-west and the property alone has a valuation of much over a million dollars, while another of the ports on which this same company is to operate, but which is located alongside a railroad right of way out in the level plains further west, is larger and better in every way, except that it is not located near a big city, but will cost but an eighth of a million in its entirety.

Unquestionably, any such amount as either of these is beyond the limit of what small cities or towns can spend. This, however, should not act as a permanent deterrent to these smaller places, for air transportation has much to offer them in its ability to connect them with the outside world, and a much smaller amount of money will provide fields or ports with limited accommodations adequate for a smaller amount of flying. With a limited amount to spend, these communities should not jump too hastily into any program, but should confer with the Department of Commerce for advice and guidance as to how to proceed.

Runways.—All of the previous discussion has been based on the development of fields of the "all over" type, or ones with their full areas turfed in a manner to permit landing or taking off at any point. In many ways these are the ideal fields and, with fair soil and drainage conditions, they will stand up fairly well under a reasonable amount of flying. With the advent of the large transport ships, however, turf fields are proving inadequate. Visualize a 5-ton truck speeding across a rain-soaked meadow at 70 miles an hour and the reason for this inadequacy is apparent. For such service hard-surface runways are needed, but these should be placed so as to interfere as little as possible with the "all over" use of the field by smaller planes. Location of these runways must be studied very carefully with due regard to prevailing winds, safety of approaches, and many other things.

Opinion as to the best materials for runways is varied. Each must be judged on its merits as to its adaptability to the prevailing soil and climatic conditions, and its economic availability. Generally speaking, it may be said that materials and applications suitable for highways under comparable conditions of soil, climate, loadings, and density or frequency of traffic are applicable to runways.

Heating.—Another feature of airport-building design that has been slighted to date is that of heating. Our organization observed and studied hangars and shops at most of the ports in the East and Middle West during this past winter. With due deference to all of them, not a single one was found that was adequately, evenly, or economically heated. Basically, a hangar is high, wide, and not particularly handsome; has terrific heat losses due to its large glass areas; and lets all out of doors come inside whenever the doors are opened to admit or emit a ship. The most marked tendency is for heat to float up toward the roof and leave the floor unbearably cold. After studying the problem from every angle the opinion was formed that the best heating would come from the installation of extremely high-velocity, large-volume, and reasonably low-temperature units in such a manner that cold air would be taken from the floor, heated to a reasonable degree, and emitted just below the bottom chords of the trusses and at angles and velocities to jet it clear across the building to impinge on the far wall where, in cooling, it would descend and travel back along the floor to the unit for recirculation. Basically, at least six air changes per hour were deemed imperative. Several of these installations are being made this spring and summer, and this time next year we shall know how well we have answered the question.

Acknowledgment.—The foregoing is a paper presented May 28th at the third national meeting of the Aeronautic Division of the American Society of Mechanical Engineers.

Data on Steam and Electric Pumping Stations

Comparison Between Pumping Plants of Four Cities

By J. F. LABOON
The J. N. Chester Engineers, Pittsburgh, Pa.

COMPARISONS of costs as between steam and electrically driven stations, including gas and oil where available at reasonable prices, are usually made in determining the most economical kind of power. A case in point is that of Wheeling, W. Va., where electric power supplanted steam, although coal was mined practically at the front door of the boiler house. The actual cost of this electric station was $310,000. The estimated cost of the steam station was $604,000. The fixed charges and operating expenses for 15 M.G.D. production at the electric station was $113,875, or a pumping cost of $20.80 per million gallons; for the steam station the total estimated cost was $133,000, or $24.30 per million gallons pumped.

Power is furnished the city water works under a special municipal tariff based on a guaranteed load factor specified at the beginning of the year, which gives an average power cost of 8.59 mills per kw.-hr. Slip ring motors were used in conjunction with a synchronous condenser to maintain unity power factor.

Costs at Nashville, Tenn.—Nashville, Tenn., has been rehabilitating its water works intensely for the past seven years, placing into operation in September, 1927, a new boiler house, boilers and auxiliaries. Electrically-driven pumps have been installed since 1926 to augment the pumping capacity. Figure 1 shows the results obtained under various conditions of steam pumpage, that is, with the old station operating a vertical triple expansion pump with one lift from the river to the storage reservoir; the improved pumping station with two horizontal uniflow engines operating vertical centrifugal pumps for low service, and a turbine-driven centrifugal pump on high service; and later with the new boiler plant in operation. The motor-driven centrifugal pumps are too recently installed to permit of any direct comparative data.

It will be noted that the station duty dropped off with two-stage pumpage with the uniflow and turbine-driven centrifugals in operation, but that this duty was materially improved upon installation of the modern boiler plant. Actual costs of operation have been omitted inasmuch as direct comparison of such costs with those of a similar plant might be productive of confusion, rather than good, since labor conditions and rates together with fixed charges vary with local conditions. Therefore, station duties have been given as a measure of economy, instead.

Pumpage at Erie, Pa.—Some direct comparison, however, can be made between the Nashville, Tenn., and the Erie, Pa., plants inasmuch as both involve in many respects the same types of pumps and conditions. Figure 2 shows station duties and conditions of pumpage at Erie. In this case, too, it will be seen that economies were depressed as soon as the turbine-driven centrifugal was put to protracted use, such as was the case in 1926 and 1927.

In computing station duties, the motor-driven units are not included. Their function in the figure is to show the proportionate use that is made of the various pumps, or types of power.

The Erie plant offers some direct comparison between costs of steam and electric-driven units inasmuch as a 12 million gallon motor-driven high service unit was installed in 1925 to augment the vertical triple expansion and the rest of the direct-acting steam units. Table I shows comparative costs of steam and electric power pumping at the main station.

In allocating charges for depreciation, the electric unit has been charged with the proportionate space it occupies in the station and labor required for operation. Power is purchased on a regular tariff basis. Electrical pump-

NASHVILLE, TENN.~STEAM STATION

PERCENTAGE OF TIME RUN

PUMPS	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
WORTH. #1 H.S	2.4	0.6	DISMANTLED								
WORTH #2 H.S	0.4	0.5	0.3	DISMANTLED							
HOLLY H.S	1.9	0.3	0.2	0.3	0.04				DISMANTLED		
ALLIS H.S	95	99	97	79.5	32	4.9	20.6	12.7	19.4		
H.S TURBINE & L.S UNIFLOWS				17.3	66	93	78	86.6	80.6		
ELECTRIC- L.S. & H.S.								12.5	12.2		
PUMPAGE MGD	13.6	14	14.9	15.1	15.6	16.	16.1	17.6	18.8		
COAL - TONS	9424	9149	10280	10967	11698	15954	14950	14635	14153		
STA DUTY MILLION FT. LBS/100 LBS COAL	71	78	73.5	73	70.5	54.5	58	62	70.3		
COST COAL PER TON	4.19	4.19	4.08	3.62	3.36	3	2.79	2.21	2.15		
GALS/FT. HEAD/# COAL	85,800	94,000	88,200	87,700	84,800	63,500	69,700	74,600	84,900		

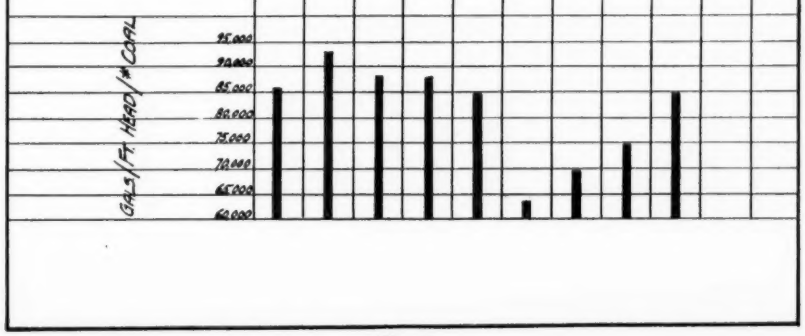


Fig. 1

Table I—Cost of Operating High Duty Pumps, Foot of Chestnut Street, for Year Ending Dec. 31, 1927

	Steam Power	Electric Power	Total	Cost Per M.G.
Superintendent, chief operator and clerk	$ 3,910.43	$ 454.25	$ 4,364.68	$ 0.496
Operating labor	7,640.64	883.42	8,524.06	.970
Steam for engines 5, 6, 7	59,263.09	.....	59,263.09	6.740
Steam for miscellaneous equipment	3,885.18	204.49	4,089.67	.465
Electric power purchased engine No. 8	.....	29,239.06	29,239.06	3.326
Lubricants and waste	415.14	.70	415.84	.047
Electric light and power produced	1,280.11	67.39	1,347.50	.153
Other supplies and expenses	523.05	27.52	550.57	.063
Repairs and maintenance:				
Buildings	3,784.71	199.18	3,983.89	.453
Engines and attachments	10,234.37	311.02	10,545.39	1.200
Miscellaneous equipment	442.44	23.30	465.74	.053
Depreciation	12,776.57	2,842.68	15,619.25	1.777
Total cost	$104,155.74	$34,253.01	$138 408.74	$15.743
Head in feet		257.5	359	
Pumpage in gallons	6,837,339,600	1,955,030,000	8,792,369,600	
Foot pounds per dollar	140,902,300	170,799,260	.....	
Average rate per K.W-Hour	.99228 ct.			

Table II—Cost of Operating Electric Pumps—Booster Station, 26th and Sigsbee, for Year 1928

	Amount	Cost per M.G. Boosted
Superintendent and Clerk	$ 832.00	
Operating Labor	3,793.06	
Electric Power	11 366.42	
Oil and Waste	4.25	
Maintenance and Repairs:		
Pumps and Motors	402.86	
Miscellaneous Equipment	166.93	
Buildings	340.51	
Heating and Lighting	255.77	
Miscellaneous Supplies and Expense	162.49	
Depreciation	1,759.44	
Cost of Boosting 1,901,445,500 Gallons or 5.2 M.G.D. from Low Service Mains at 26th and Sigsbee to High Service Reservoir, a head of 96.2 ft.	$19,083.73	$10.036
Foot Pounds, per Dollar of Cost	79,700,000	
Average Rate of Power per K.W.H.—1.337 ct.		

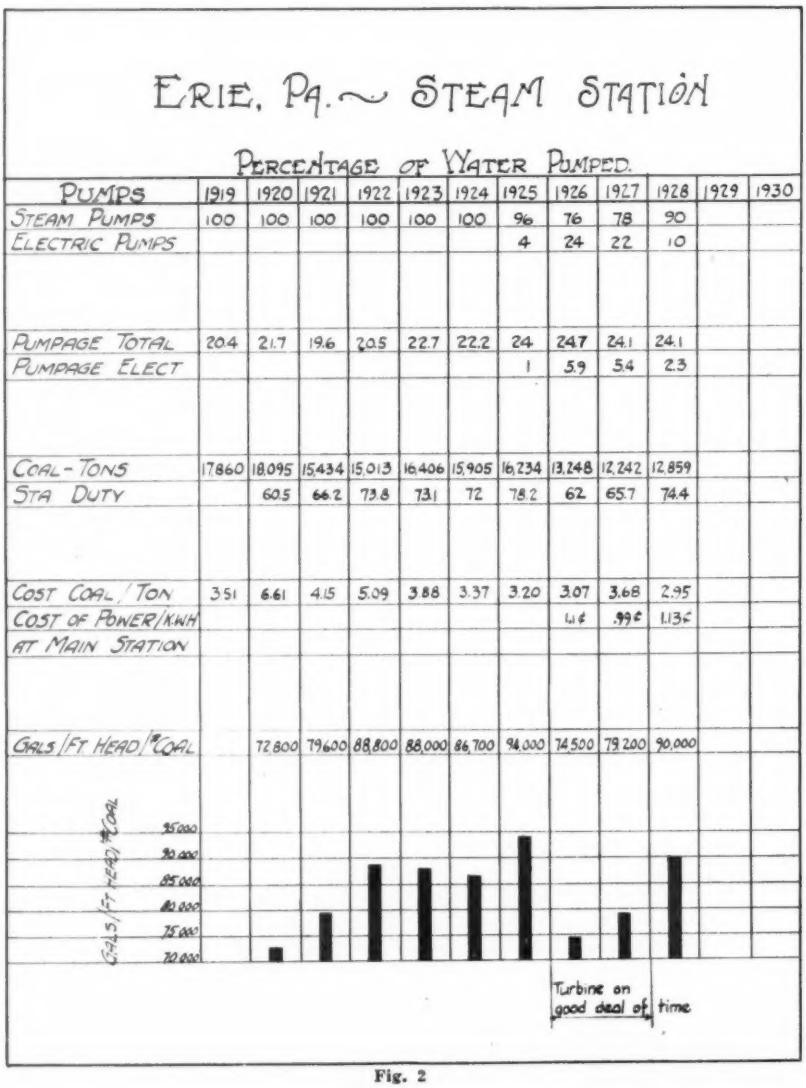


Fig. 2

ing in this case is justified by virtue of its economy. The difference in heads is due to the use of the electrical unit on Booster service head, but this difference has been wiped out by the installation of a new Booster station. The impeller of the 12 M.G.D. electrical unit has been cut back to permit of greater efficiencies at the reduced head under which the pump operates now. The pump was out of service for six months in 1928, pending the change in the impeller. Therefore, the pumpage by this unit was only 10 per cent of the total during that year as shown in Table I.

Cost of Operating Electric Pumps.—A new booster station consisting of two 5 M.G.D. and one 8 M.G.D. motor driven units has been completed to relieve the head conditions at the old station. This station has been in operation since December, 1927.

Costs and economies are given in Table II for the Booster station, electrically operated, for the year 1928.

Power for this station is costlier than that for the electrical pump at the main station, and this coupled with low head pumpage, combine to reduce economies somewhat below those found for the 12 M.G.D. unit at the main station. It is of interest to note that the new 16 M.G.D. pumping station and filtration plant now being designed for Erie, as an additional supply, will be electrically operated.

Steam Pumpage at Fostoria, O.—In contrast to the trend towards electrical pumping units as exemplified in the preceding paragraphs, is the case of the pumping station at Fostoria, O., where a study developed that it was more economical to install a cross-compound steam pump than an electrically driven centrifugal pump for high service. Table III gives the details of the comparison of costs as be-

Table III

Actual Cost of Steam Equipment

3 M.G.D. Cross Compound Pump	$23,500
Pumping Foundations and Building	8,200
Two (2) 3 M.G.D. Engine Driven L. S. Pumps	4,100
Foundations	500
Water and Steam Piping	9,300
	$45,600
Engineering and Contingencies	4,400
Total	$50,000

Estimated Cost of Electrical Equipment

6 H. S. & L. S. Pumps Installed	$ 9,000
Foundations	1,000
Piping	7,000
Improvements to Pump Room	2,000
	$19,000
Engineering and Contingencies	2,000
Total	$21,000

Annual Fixed Charges and Operating Expenses —2 M.G.D. Production

Steam

Interest and Depreciation	$ 4,000
Oil, Maintenance, Etc.	500
Coal	4,000
Total	$ 8,500
Cost per Million Gallons—$11.60	

Electric

Interest and Depreciation	$ 2,000
Maintenance	300
Power	14,000
Total	$16,300
Cost per Million Gallons—$22.50	

tween steam and electrically driven pumping stations.

Power costs were computed from the regular tariff in force at the time. No saving in labor can be made with electrically driven units since the steam plant including boilers and pumps has been operated by one man per shift. New boilers were installed in 1925, so there was no need of improvement in the boiler plant, and no charge is made on this account in the comparative statement. It is interesting to note in this case that the total cost per million gallons pumped with steam equipment was approximately one-half of that for the electrical equipment. The steam station improvements were finally installed.

It is of interest to note that a few days ago the Water Department Engineers of the City of Pittsburgh decided to electrify one of its largest stations, which will have a capacity of 80 million gallons per day. Current is estimated as costing 6.5 mills per K.W.H.

While increasing use is being made of electrical power for actuating pumping machinery, fundamental principles still hold good and must be applied to every situation where the question of improving the pumping station comes up, in order that a sound decision may be made.

Acknowledgment.—The above is an abstract of a paper presented at the 49th annual convention of the American Water Works Association.

The Trenton Sewage Treatment Plant

Notes on the Second Year's Operation

By P. N. DANIELS,

THE outstanding features of the second year's operation of the Trenton sewage treatment plant were, first, the absence of foaming, and second, the economical disposition of the very large quantities of sludge produced.

Trouble was experienced during 1927 with all of the twelve Imhoff tanks foaming during August of the year, the plant having been started in May. At a plant of this size, design capacity 25 millions gallons per dav, with 12 tanks each 144 ft. by 33 ft., control methods in practical use for smaller installations cannot be economically adapted on a large scale, particularly seeding and lime addition by solution. As the tanks had to be started without seeding, the fresh solids-ripe sludge ratio could not be established, and as a consequence, severe foaming resulted as soon as digestion was well started. Liming was resorted to from the start and undoubtedly minimized the foaming period, but the application was not as efficient as it might have been due to the fact that the lime had to be sprinkled dry over the gas vent scum and then pushed or hosed down. The installation of apparatus for thorough admixture either by solution or return pumping of sludge was out of the question as being prohibitively expensive so that undoubtedly a certain amount of the lime was wasted and had no effect. This was demonstrated by the fact that the sludge when drawn showed many particles of undissolved lime present throughout the mass.

After the foaming ceased, liming was continued through the winter to maintain a pH of 7.3, the amount used being 110 lb. per million gallons on the average. Contrary to expectations, the advent of warmer weather did not decrease the lime demand but increased it for the maintenance of a 7.3 pH, this possibly being due to larger increments of mash from the uptown illicit distilleries in amounts so great that from ⅛-½ of the grit was rye kernels, producing, of course, very acid conditions in the tanks. It has been the policy from the start of operation to use one of the twelve tanks as a control (we are functioning at about 75 per cent of design capacity) for the purpose of studying various operating procedures and the determination of the most economical routine.

This control tank was not limed after foaming had ceased and the pH dropped as low as 6.4, but it was found that digestion, although somewhat slower than the others, proceeded in normal fashion with production of very good sludge. Laboratory tests demonstrated the same facts, so starting the first of August, 1928, no lime was added to any of the tanks, the pH dropping in all to an average of 6.6. No foaming or other undesirable effects followed, the sludge output being consistently of excellent quality.

It is not to be inferred from the above that this disproves the beneficial effects of pH control at an optimum of pH 7.3-7.6 by the use of lime where required, as the circumstances at the Trenton plant are not the same as elsewhere. In the first place, the Trenton sludge, due to the iron content of the sewage (as high as 800 ppm.), digests far more rapidly than straight domestic sludge so that we can keep the fresh solids-ripe sludge ratio at a high figure, even with a sludge capacity per capita of about 1.98 cu. ft. This feature is fully discussed by Dr. Rudolfs in another paper. In the second place, if we can obtain the desired results, good sludge digestion without disturbance of sedimentation efficiency by foaming, without the use of lime, it is uneconomic to add lime merely as an accelerant to digestion. The time will arrive with growth of population and increased sewage flow when to postpone the necessity of plant additions, it will probably pay us to expand our sludge storage capacity by more efficient digestion using lime.

To maintain this high fresh solids-ripe sludge ratio, the hoppers are kept filled to the 18 in. zone and only small quantities of sludge are drawn at any one time. The flexibility of our sludge disposal system permits this, as explained later.

So far, April, 1929, the sludge digestion is proceeding normally with no foaming even though the weather has been unseasonably warm, and from all indications 1929 will be a repetition of 1928 as far as freedom from plant disturbances is concerned. The writer is not inclined to be over optimistic, however, when it comes to predicting the future course of events at a sewage treatment plant handling a wide variety of trade wastes and will qualify the last statement by stating that we do not anticipate trouble if the sewage constituents remain as they are now. Our distillery industry is apparently on the wane, judging by mash receipts, and also by newspaper reports of a widespread "back to the farm" movement on the part of our best bootleggers. This one item, the lessening of the mash content of the sewage, is bound to help a great deal towards the maintenance of proper digestion conditions.

Another factor which assists very much is the use of lime for pH control of corrosion at the Trenton water filtration plant, started early this year. The water supply, formerly below pH 7.0 at times, is now kept uniformly at pH 8.6—this is of course reflected in the pH of the sewage and the sewage sludge.

We started to lagoon sludge by pumping from the sludge alleys to a 12-in. cast iron pipe formerly used for scum removal. This method, while a great saving over the customary sand bed drying procedure, was bothersome in that the pump had to be kept going all the time to keep ahead of the sludge accumulation. Each sludge alley (six in all) has a 4-in. connection to a 6-in. water main and it was found that by a simple rearrangement of valves we could back up the sludge enough to give the head necessary to force the sludge to the lagoon by gravity. A few trials proved the feasibility of this method and the pumping was discontinued. At the present time only enough sludge is put on the sludge beds to supply the demand from farmers, florists and others, and the rest is lagooned. No trouble has ever been experienced from this lagooning due to odors, flies, or other causes. Approximately 500,000 cu. ft. of sludge (wet) is produced yearly, per cent moisture around 89.5.

The summary of the year's activities follows:

Total flow for the year, m. g.	5,841
Average daily flow	16.0
Total expenditures	$51,000
Operating cost per million gallons gross	8.73
Operating cost per million gallons pumping	4.36
Operating cost per million gallons treatment	4.37

Acknowledgment.—The above paper was presented at the 1929 meeting of the New Jersey Sewage Works Association.

Valves and Hydrants

Their Distribution, Installation and Maintenance

By C. S. HOWARD
General Manager, Iowa Valve Co., Des Moines, Ia.

THE number of valves and fire hydrants in a distribution system is a field in itself, many consider, however that there should be a valve at least every 500 ft. in a mercantile section and at least every 1,500 ft. in a residential section and for reduced pressures, cross sectioned to permit free circulation and no dead ends. This is a somewhat ideal arrangement, but will be found extremely satisfactory from a maintenance standpoint, and efficient service.

Spacing of fire hydrants is usually a matter of local determination with due regard to be given to property to be protected and the saving of hose and pressure. The loss of head is estimated to be around 18 lb. per hundred feet of hose. Therefore, economy is often made in having too many rather than too few. Various rules are given: 200 ft. in mercantile districts, 500 ft. maximum anywhere.

Installation of Valves.—No valve should ever be installed without a record being made of the size, manufacture, location and cost of installation together with the date of last inspection and by whom made. We know of many systems in which the only record is in the memory of someone since removed or dead.

We know many towns in Iowa and other states, in which there is not a single record of any valve, and many in which the only valves are right outside the pump house. We know of one city in which a certain section complained of poor pressure. A new main was considered and engineers were hired. It developed that a large valve was all but closed on a supply main. Hence the necessity of records.

We also suggest here that no valve be operated by any other than an experienced man, who is responsible to either the company or fire department if a hydrant is operated.

Valves are usually made of cast iron, usually thoroughly tested to a hydrostatic test of 300 lb. factory and found perfect or they would not have been shipped. But in shipping it may have been subjected to very rough handling, so always be sure before putting a valve in the line to give it a hammer test. It may save time and money if the defect is observed before putting on pressure.

When flanged valves are used see that the fitter shows a little sympathy for the valve, and brings the pipe to the valve, not the valve to the pipe. It is not an uncommon practice for a fitter on a pipe line to use the valve bolts to draw up 2 in. or 3 in. of separation. He may get by but what about the valve when pressure is on, or if the pipe line sags months later?

When installing valves, care should be used to see that the gates are securely closed, especially with screw and flanged types; it not only keeps the dirt and grit out of the valve which might scratch the seats, but adds strength and rigidity to the valves against strain of screwing or bolting the flanges.

With screwed end types, see to it that the pipe is not too long. The pipe may ruin the valve seats. Also never permit pipe compounds to be put on the threads of the valve, only on the pipe, for if put on valve threads, it may be pushed into the valve and cause trouble and expense.

A bad practice with screwed end valves is to permit or allow the wrench to be used on the end farthest from the pipe. The strain and leverage of a long wrench may spring the valve body slightly, and thereby warp or ruin the seats. Rest assured it was all right when it left the factory; therefore, if trouble occurs, the chances are the wrench was not used on the side next to the pipe.

Packing of Valves.—Many valves are observed to leak around the packing after having been in service a considerable length of time. This is often due to lack of oil on the packing or the poor quality originally used. From our standpoint, we prefer and use a braided Italian hemp packing that has been boiled in paraffin. By adding a little graphite this seems to be durable, does not corrode the stem to any marked degree, and by adding oil to the stuffing box with a long-necked oil can once or twice a year or at the time of the yearly inspections, adds material life. Especially is this true in warm climates. As to how often a valve needs packing, seems to be a matter of how often it is operated as well as local conditions.

Maintenance of Hydrants.—I know of no better rules than adopted by New Orleans which are as follows:

1. Open a fire hydrant slowly, and steadily, and always enough to prevent any chattering of the main valve, even if more water is drawn than is required.

2. If the fire hydrant is to be left open, with pressure available for self-closing or other faucet, or valve, on its outlet, for intermittent use, open it slowly, until the hydrant is full open, then release the operating nut by one turn backwards. Where a hose bib or other connection is placed on hydrant, care must be used to see that rubber gaskets are placed under the nozzle caps.

3. Close a fire hydrant very slowly, especially as the valve approaches its seat, until it comes firmly to its seat, and then release tension on valve and stem by one turn backwards of operating nut.

4. After closing a fire hydrant, see that the caps are properly replaced over its outlets.

5. Do not allow a fire hydrant to run for gutter flushing after the flow in the gutter becomes reasonably clear.

6. Use no tools to operate a fire hydrant other than a close fitting five-sided wrench furnished by the Sewerage and Water Board. If wrench becomes worn, so that it injures the operating nut, turn it in and obtain a new one in its place.

In the city of Akron, O., which I believe was the first city to put the hydrants in charge of the Fire Department, men are regularly sent from each department to inspect, operate and report the condition of each hydrant. No one is allowed to open a hydrant, but a fireman who is available for duty when called by contractors, etc. His time is then charged in the service by the water company.

In these days of automobiles, trucks and wild drivers, every fire hydrant should have a valve between it and the main. When a line has 80 lb. or more pressure and the hydrant is broken and spouts, of what use is a valve set directly in front of the hydrant. You can't get at it to close it off. Therefore, have the valve in the street not inside the curb or next to the hydrant.

Inspection of Hydrants.—Hydrants besides being systematically inspected at least every spring and fall should further be inspected after use, during the winter by a competent man, familiar with its construction and operation.

Every hydrant to be properly installed should rest on a solid stone or concrete base preferably broad at rear and have coarse gravel, bricks or the like, but no ashes, dumped around the base, then on top of this, straw should be placed. The reason for this straw is that in back filling by water the straw collects and prohibits the dirt from packing into the gravel and thereby permits ready drainage from the hydrant. Many cities connect every hydrant drain with the sewer. Where roots are liable to creep into the drain barrel of the hydrant, it may also be desirable to dump rock salt or copper sulphate in with the gravel. I have seen hydrants completely put out of commission because of roots.

However, salt in certain soils is very hard on cast iron so care should be used to prevent its coming in contact with the iron. For this reason, use of copper sulphate is strongly urged, although more expensive.

Hydrants, if properly installed, used and inspected, should last for years, for they generally wear out from abuse rather than use.

Acknowledgment.—The foregoing is an abstract of a paper presented to the second annual Iowa Water Works Conference.

The East Side Sewage Treatment Plant of the City of Topeka, Kan.

Exemplifies Many of Recent Developments in Sewage Treatment Practice

By CHARLES A. HASKINS
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THE East Side sewage treatment plant of the City of Topeka, Kan., now under construction, is of such a type that a description of the features of the plant will illustrate many of the recent developments in sewage treatment practice. This plant is designed to serve a population of 54,000 with an average daily sewage flow of 5.4 million gallons. Part of the sewer system is on the combined plan, but the bulk of the storm water will be bypassed directly into the Kaw River. The dry weather flow of the existing outfall sewer will be collected by an interceptor and conducted to a pumping station, from which it will be pumped through about 500 ft. of 30-in pipe to the treatment plant.

This plant is being built for primary treatment only, though it has been so arranged that activated sludge units can be added in the future. It is of the separate sludge digestion type. The units of the present plant include a bar screen, grit chamber, two 70 ft. square settling tanks, two sludge pumps, two 65 ft. circular sludge digesting tanks of the closed type, 28,800 sq. ft. of sludge beds, and a general building which houses the sludge pumps, the sludge heating equipment, the bar screen, and the grit chamber mechanism. The building also provides office laboratory, garage, shop. and storage space, and toilet conveniences for the operators.

Bar Screen.—At the plant the sewage will pass first through a bar screen having ½-in. openings. This screen is of the Dorr type, mechanically cleaned by a revolving rake arm, the screenings being deposited on a perforated drainboard. From this drainboard the screenings will be hand raked at intervals into a galvanized iron chute and will fall by gravity into a gas fired incinerator located on the floor below the screen unit. The incinerator may be run continuously or intermittently as the volume of screenings requires. Both the screen and incinerator are housed in the general building.

Grit Chamber.—After flowing through the screen the sewage passes into the grit chamber. This grit chamber is of a type very recently developed by the Dorr Co., and is known as a detritor. The detritor consists of two essential parts, a settling tank with grit collecting mechanism, and a washing compartment with grit cleaning and discharging mechanism.

The settling tank is of concrete 26 ft. square and with a water depth of about 2 ft. at normal flow. The sewage enters along one side through a series of gates which are made adjustable for the purpose of distributing the flow evenly over the tank, flows across the tank and out opposite side over a sharp crested weir running almost the full length of the side, and into an outlet channel, from which it is conducted through pipes to the main settling tanks. The grit collecting mechanism consists of four radial raking arms on the floor of the tank, suspended from an oscillating truss, one end of which is pivoted on a pier at the center of the tank, and the other end of which is propelled by a motor along a rail which runs around the periphery of the tank. In operation, the radial raking arms sweep the settlings toward the outside of the tank, and at a point on one side of the tank they are forced into a chute leading to the grit cleaning compartment. This cleaning compartment is an inclined trough built against one side of the tank proper. It is 15 in. in width and about 25 ft. in length. Since it is inclined, the lower part of it is below the water surface, while the upper part is above the surface. The cleaning mechanism consists of a series of reciprocating rakes hanging in the trough, and supported from above. These rakes move the settlings up the inclined floor of the clearing compartment to a discharge point at the upper end. During this movement up the inclined floor, a rolling action is imparted to the settlings, and since they are under water during the first part of the travel, there is effected a separation of the heavier grit and the lighter organic matter. The organic matter is conducted back into the tank through a bypass from the cleaning trough.

This unit is a very recent development, and information on actual operating results are very meager. The machinery, however, is practically the same as has been used for some time in mining and metallurgical operations and is well worked out as to details. A unit of this type, designed to handle 2.5 m.g.d. has been in operation for more than a year at Harrison, N. Y., and is removing 90 per cent of all grit over 100 mesh, with only 2.5 per cent of putrescible organic matter left in the grit.

The mechnical washing of the collected grit seems to be a decided advantage. The chief trouble with grit chambers is that, in order to catch the grit at times of high flow it is necessary to have very low velocities through the tanks at normal flow, and most organic matter is settled out with the grit. In the Topeka installation the velocities through the tank will vary from 0.2 to 0.4 feet per second, and some organic matter will no doubt be settled out, but will be later returned to the sewage from the washing compartment.

A novel arrangement has been provided for the removal of the grit from the site of the plant. At the upper end of the cleaning trough the grit is dropped into a hopper the bottom of which is about 5 feet below the surface of the water in the outlet channels of the main settling tanks. A six-inch pipe is laid from the outlet channel to the grit hopper, and a four-inch pipe from the bottom of the grit hopper to the outfall sewer, about 10 ft. below the hopper. Water will be allowed to flow from the outlet channel of the settling tank to the grit hopper, and flush the grit into the outfall sewer. The velocities of flow in the outfall sewer will be as high as those in the force main coming to the plant, so the sewage should be able to carry away all the grit it has brought to the plant.

Settling Tanks.—There are two settling tanks 70 ft. square and 8 ft. deep, equipped with Dorr traction type clarifier mechanisms. These mechanisms consist of radial sweeping arms on the bottom of the tank, suspended from an oscillating truss which is pivoted at one end of a pier in the center of the tank, the other end being propelled by an electric motor along a rail on top of the walls of the tank. The oscillating truss extends itself as the propelling mechanism approaches the corners of the tank, which are slightly rounded, and shortens again as the mechanism leaves the corner. The raking arms at the bottom of the tank sweep the settlings into a sump at the center of the tank, which is tapped by the suction pipe from the sludge pumps.

These clarifying tanks are designed for a 2½ hours' detention period. The sewage flows along one side of the tank in a channel designed to keep a constant velocity at all points, and enters the tank over weir plates extending over about 70 per cent of the width of the tank. After flowing across the tank it discharges over similar

weirs into an effluent channel leading to the outfall sewer. These weirs are in 6-ft. sections and are all adjustable.

In an effort to prevent any accumulations of floating matter on the surface of tanks, it was decided to omit all bafflewalls, leaving an unobstructed water surface from the inlet to outlet. It is possible that there may be some circuiting or streaming effect across the surface of the tanks, in which case provision is made for the installation of baffles.

Digester Tanks.—There are two circular digester tanks, 65 ft. in diameter and 23 ft. deep, equipped with Dorr sludge agitating mechanism. The tanks are designed to provide a sludge capacity of 2.5 cu. ft. per capita. The floors of the tanks slope slightly toward conical sumps in the center. From these sumps 10-in. sludge lines lead to the sludge beds, and 6-in. suction lines lead to the sludge pumps in the building. These suction lines are provided so that the sludge in the tank may be circulated by pumping.

The sludge agitating mechanism revolves on a central shaft suspended from a truss bridging the tank, and consists of radial scraping arms for stirring the sludge at the bottom of the tank, and radial arms near the top of the tank for keeping the scum broken up.

An overflow is provided for carrying off some of the supernatant liquor in the tank when fresh sludge is being added. This overflow leads to an outlet beneath the surface of the water in the detritor tank. Means are also provided for drawing off any scum which might collect in the gas domes.

These tanks are equipped with concrete covers and gas domes for the recovery of the gas formed by the digestion of the sludge. The gas is piped into the general building where some of it is used in the incinerator for burning screenings. The bulk of the gas, however, will be burned in water heaters and the hot water circulated by pumps through pipe coils inside the digester tanks for the purpose of keeping the digesting sludge at a temperature favoring rapid digestion. The building will also be heated by the hot water. A daily production of about 30,000 cu. ft. of gas is expected when the plant is loaded to the designed capacity.

Sludge Pumps.—The two sludge pumps, for pumping the settlings from the clarifier tanks into the digester tank, are located on the main floor of the general building. They are diaphragm pumps of the Dorr type capable of handling 50 gal. per minute of 95 per cent moisture sludge each. Six-inch suction lines lead from the bottom of each of the clarifier and digester tanks to the pumps and 4-in. discharge lines lead from the pumps to the tops of the two digester tanks. These suction lines come together in a header located in the sub-basement of the building directly below the pumps. The suction and discharge pipes are so arranged that it is possible to:

1. Pump from either clarifier, with either pump, and discharge into either digester tank.

2. Pump from the bottom of a digester tank into the top of the same tank.

3. Pump from the bottom of one digester into the top of the other digester.

4. By an easily completed cross connection, it is possible to flush out any of the suction or discharge lines with city water under pressure.

5. All the suction lines enter the basement and terminate in wye branches, the branch of the wye leading to the suction header and the straight part being capped with a blank flange. By removing these flanges it is possible to rod out any of the suction lines, as they are laid perfectly straight.

Considerable thought was given to the layout of this piping and it is believed that an arrangement has been obtained which will allow of considerable flexibility in the operation of the various units of the plant.

Sludge Beds.—There are no unusual features about the sludge beds, but it is believed they are in line with the latest practice. There are 8 beds each 30 by 120 sq. ft., grouped together, providing 0.5 sq. ft. per capita. The sludge lines leading to the beds are so arranged that the sludge from either of the two tanks can be discharged on to any one of the eight beds. The filtering material consists of 6 in. of sand and 12 in. of crushed rock underdrained by lines of 4-in. tile at 5 ft. centers, laid with open joints. For removing the dried sludge, an industrial railway with push cars is provided. A main line is laid along one end of the battery of beds, with a turntable and stub track leading into each bed. Final disposal will be made by filling in several acres of land adjacent to and 10 ft. below the general level at the plant.

Appearance.—Since the plant is located adjacent to a residence district an effort was made to effect a pleasing appearance. All units are so arranged that they are symmetrical about the center line of the plant, and the earth grades and drives have been worked out so as to set the structures off to best advantage. There will be no overhead wiring about the plant, it all being carried in undeground conduit. When the plant is completed an effort will be made to get the city to beautify the grounds with grass and shrubbery.

Odor Control.—In the design of both the pumping station and the plant, the question of odor control was very important, as both units were of necessity located very close to residence districts.

In the pumping station an attempt was made to prevent the settling out of grit and heavier organic particles in the wet well, which is usually a serious source of odors. The floor of the wet well is to be formed into well defined and fairly narrow channels, so that when the sewage is drawn down near the bottom it will flow in these channels to the pump suctions with enough velocity to scour the bottom clean. Arrangement is also made to chlorinate the sewage at the pumping station, in order to keep it in a fresh condition while it is passing through the plant.

At the plant all reasonable precautions are provided for eliminating odors. Screenings and grit which are removed from the sewage will be disposed of promptly and in an inoffensive manner. The settling tanks have been arranged to prevent, as completely as possible, the accumulation of floating matter. Baffles have been eliminated and all corners likely to collect and hold deposits have been filled in. The digesters are of the closed type, and all gas issuing from them will be burned. The sewage is conducted about the plant, not in open conduits likely to collect deposits, but in underground pipes. Hydrants are provided about the plant furnishing city water for flushing and cleaning.

The fact that modern practice makes for the better control of odors has been a real economic advantage at this plant. Had it not been possible to control the odors so closely the plant could not have been located at its present site, and the next available site is about a mile farther from the pumping station. The use of the farther site would have added about $50,000 to the cost of the force main.

Chlorination.—It will be necessary during periods of low flow in the Kaw River, to chlorinate the effluent from this plant for the purpose of relieving the load on the water treatment plant at Lawrence, about 30 miles downstream. The sewage will also be chlorinated at the pumping station for the purpose of reducing odors at the plant. Since there will be a considerable consumption of chlorine, it has been arranged to handle the chlorine in drums containing one ton, instead of the small 150 lb. containers. This will effect a saving of from 35 to 40 per cent in the cost of the chlorine, and also a considerable saving in freight. The advantages of using chlorine in ton containers are well worth considering in any case where a large quantity is to be used.

Acknowledgment.—The above is an abstract of a paper presented before the Missouri Water and Sewerage Conference.

Aberdeen, Wash., May Buy Local Railway.—Legal proceedings leading to the acquisition by the city of the Grays Harbor Railway, Light & Power Co. of that district have been authorized in a communication from the city council granting to Mayor H. E. Bailey power to employ special counsel and to proceed with the necessary steps to procure the facilities.

Ethics for Engineering Services

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UNQUESTIONABLY, one of the most gratifying changes which has taken place with respect to the engineering profession during the last century is the recognition of the fact that the engineer is not purely a technician, but that many engineers are endowed with broad common sense, judgment and executive ability. Whereas formerly men serving in public office, on national and state commissions, or selected as the executives of large corporations were drawn almost exclusively from the field of business and the legal profession, it is very common to see engineers selected at this date, and there is reason for this, for no training serves as well to fit a man for executive work, if he has innate executive ability, as the training of the engineer. The recent attempt, however, of engineers to push or promote the engineer for executive or public positions, just because he is an engineer, is in my judgment erroneous, because that is a matter of individuality. The engineer with the qualities and equipment necessary for an executive and with a leaning towards executive or public work will gradually emerge from the practice of engineering into executive fields, and will command the same respect and attention as a man of the same qualities and equipment who emerges from the profession of the law or medicine.

In saying this I do not wish to belittle the professional work of an engineer. On the contrary, there is a grave question in my mind whether the professional work of an engineer, although possibly it does not bring the same emoluments, is not equally as important and as meritorious as the work in the executive field. Notwithstanding this fact, the engineering profession must recognize that as the profession grows and this country is stabilized there is going to be a greater and greater demand for executive engineers, and the educators in our engineering schools should, in designing their courses, bear this fact well in mind.

Engineers as Voluntary Advisers.—It may be well in this connection to call attention to the pitfalls which await the engineer when he assumes the responsibility of a voluntary adviser in civic affairs.

When working by himself and entirely on his own initiative the engineer who takes up civic questions is likely to be cautious in his public utterances and to confine himself to fields in which his personal knowledge, experience and professional reputation qualify him to speak or write. On civic committees, however, the engineer is only too prone to go into fields outside of his own and presume to speak or write without authority. This is a mistake, and an injury to the profession, particularly in the event specialists are employed to advise with committees on which he may be a member. It is only in cities of considerable size, and not always then, that local engineers are available to deal authoritatively with highly specialized subjects. Whenever an engineer or engineering committee, not provided with funds to call in someone who is really expert on the subject in question, assumes the responsibility of giving advice, there is always a danger of serious error, and there is also the danger resulting from the fact that the average citizen is apt to think that an engineer is an engineer no matter what the questions involved, and because an engineer or group of engineers in their midst is willing to supply information and advice gratuitously it is quite unnecessary to engage engineers and pay them for detailed engineering services. The engineer can do no greater service to his profession than frankly to admit his lack of knowledge on specific questions. He does not hurt himself by so doing, for no engineer can be expert on all subjects. When an engineer serves on public committees which have to deal with technical questions he can perform no greater service than to advise his fellow citizens of the necessity of securing expert advice. The medical profession is far and away ahead of the engineering profession in this regard. The doctor does not hesitate to advise calling in a specialist and by so doing he does not feel that he is depreciating himself in the eyes of his patients. In fact, the very act of calling in expert assistance ennobles the profession. It leads the public to have confidence in the engineer and the engineering profession as a whole. The future development of engineering depends largely on an appreciation of the responsibility of the individual engineer when he accepts service on public committees. It is desirable that the engineer should be public spirited, but he may, unfortunately, do a great injustice to the profession unless he appreciates the necessity of expert advice.

Utility Management and Finance.—A great field of usefulness for engineers has developed with the growth of municipally owned utilities, particularly in the field of water works management and financing. The rapidly growing percentage of engineers on water works staffs is pleasing because it shows an increased recognition of the value of engineering in this field. The public water supplies of this country are in general municipally owned, but they have an enviable place among public utilities.

How are our public water supply systems to attain even higher standards than have been maintained in the past? The answer is: More efficiency in administration, finance and operation, as well as sound engineering design and construction. In saying this, the importance of sound engineering is not to be depreciated, for that is vital. What the water works of today needs most, however, is freedom from partisan politics and independent administration. Freedom from politics can be obtained by the education of the public and proper city charters which isolate the water department and treat it as a utility. The success of any business enterprise depends upon its conformity with the fundamental laws of political economy. The United States Supreme Court and other courts have held that when a municipality engages in the water business it conducts a commercial enterprise and is subject to the same rules at law as a private company engaged in the same business. The water department should, therefore, be maintained as a separate entity and be made responsible for the establishment of rates which will secure the revenue necessary, not only for its operation, but for financing new issues of securities necessary to meet the development of the service. All water revenues should be returned to the water department and applied by it to the needs of that department. In other words, the water works should be self-supporting. Water revenues should not be robbed for the benefit of other city departments and the water service thereby crippled. To rob the water department in this way is not only precarious, but is unjust to the water consumer, who should not have his water bill increased to ease taxes for sewers, pavements, or other purposes. Engineers as a whole, I think, recognize this principle, and the members of the American Water Works Association can do a great public service by helping to educate the public to an appreciation of the necessity of treating municipally owned utilities as private utilities would be treated.

The Engineer and the Contractor.—The laws of most states and municipalities require that public contracts should be awarded to the lowest responsible bidder. This, no doubt, is the outgrowth of the lack of public faith in the public officials of the past. Every one of you must recognize that serious trouble could be avoided and better work secured if municipal officials could call upon qualified contractors for special work, but, unfortunately, such dis-

cretion vested in official bodies has been abused in the past. Whether the abuse which would arise from allowing the municipal engineer to select qualified contractors for specific work outweighs the municipal losses sustained by the rule of awarding to the lowest responsible bidder is seriously to be doubted.

A great improvement in the integrity and honesty of municipal officials has developed in the last two decades, and everyone knows that the rule of awarding to the lowest bidder requires that the city officials be prepared to deal with the man who submits the lowest estimate for the work to be done, irrespective of his proficiency. As a result of this condition, it has been absolutely necessary that contracts be so drawn as to give the engineer the whip hand when he is forced to deal with unqualified or unscrupulous contractors. Many of the contract clauses which appear excessively harsh are a direct reaction from this method of letting work.

The engineering profession, by upholding a high ethical code in its membership, can re-establish the public confidence in city officials, and by so doing make it possible to deputize to the city officials the discretion necessary to secure competent contractors for public works. If this were done, many of the contract clauses which are now found in all municipal contracts could be toned down. Such a modification would not only be of benefit to the municipalities, but would be a decided advantage to responsible contractors.

I am a hearty believer that the engineering profession can accomplish a great work by giving the contractor a square deal, and anything that tends in that direction will be beneficial not only to the contractor but to the profession and to the clients represented by the profession. What I desire above all things to bring to your attention is the failure of many engineers to give the contractor a square deal, to tell him fully and openly what they know of the conditions surrounding the work which he is to perform, as well as what they do not know, to the end that he may judge for himself concerning the risks and uncertainties of the proposed work.

I would also appeal to engineers to assume their own responsibility, to take the blame where they are to blame, and not to fall behind the broad but stringent clauses found in most public works contracts.

The reactions against these clauses are found in recent decisions of the courts. More and more the courts are finding that the mere writing of a clause in a contract does not make it binding, that a contract is based on equity, and that the contractor has rights as well as the owner. As a matter of fact, contractor and owner have a joint interest, namely, to do the work required as cheaply and as well as possible, and it profits no engineer to indulge in sharp practice upon the contractor. On the contrary, it profits him to help the contractor as much as possible. These principles have been recognized for years past, and yet how frequently we find the rulings of engineers on the interpretation of contracts and specifications overruled by the courts to the loss and detriment of the owner.

Such conditions not infrequently are the indirect result of competitive engineering bidding, and constitute one of the evils which follow in the wake of this practice. Engineers who fail to ask for the compensation necessary to enable them thoroughly to make preliminary investigations and prepare plans and specifications based on accurate data not only hurt the profession, but do an injustice to the contractor who bids on incomplete plans and specifications, and as a result thereof exposes his client to loss. May I ask this association to help in this regard?

Engineering Ethics.—It is pertinent to ask whether the ethics of our profession has developed to the same extent as has the practice of engineering in the last century. I don't know how you feel about it, but it appears to me that unless engineers unite and insist upon high ethical standards in the practice of their profession, it is doomed to ultimate commercialism.

It is perfectly true that as this country develops it becomes increasingly difficult, nay, wellnigh impossible, for the engineer to develop a private practice by hanging out a shingle and awaiting the advent of clients seeking his services. On the other hand, there is no reason why the approach of the engineer seeking new engagements should not be professional, dignified and reserved, and there is no reason why he should in any way lower the standards of his profession or do injury to a brother engineer in so doing.

A custom much to be condemned and which, if not corrected, will certainly react detrimentally to the profession, is to be noted. I refer to competitive bidding.

Nearly all of the professions recognize that it is unethical to compete with a fellow member for employment on the basis of professional charges by reducing his usual charges and attempting to underbid his competitors. Yet this is growing to be quite common among engineers.

Recently the city of Saratoga invited competitive bids for engineering and it was surprising to see that a number of engineers responded. A year or two ago Los Angeles felt called upon to advertise for outside engineering work and to award it to the lowest bidder. Even the Port of New York Authority some time ago extended an invitation for proposals to carry out certain important bridge designs. It called for bids on price and time of delivery of expert engineering services, services involving a very high type of specialized engineering skill and trained judgment, in precisely the same way that one would ask for price and time of delivery on coal or brick. This, so far as I know, is the first time a responsible and well informed public authority has resorted to the bidding system of selecting a professional man to direct the expenditure of large sums of public money.

This is bad professional practice, the evils of which are sufficiently self-evident to require no argument or proof. It is difficult to see any justification for it, and engineers who have regard for their profession certainly should not help such practices by submitting bids for engineering services.

I am sure that the men of the old school of our profession would have scorned such a proposition, and I think it is up to associations like this to combat the tendency by making it apparent that members who participate in such practices are not welcome to the profession.

It may not be amiss at this point for our own edification to dwell for a moment upon some of the older men of our craft with whom as youths we were associated, and to recall the dignified poise of their bearing, the outward sign of an inward consciousness of right doing which resulted from long years of sacrifice to their calling, to remember their rugged, simple characters, their allegiance to accuracy and truth, and devotion to duty growing out of a love of their profession and the lack of desire for personal gain, and ask if the profession of today is actuated by the same high motives. I leave you to make answer.

Engineering Fees.—We find much complaint among engineers of the small remuneration which they receive. How can the engineer expect consideration from the public and a proper appreciation of his services when he depreciates his own services by failure to uphold the ethics of his craft? Conceive, if you will, of a body of lawyers submitting competitive bids for legal services, or a group of doctors bidding for the cure of a case of illness or for performing an operation. No one would dare approach a lawyer or a doctor on any such basis, and there is no more reason why the engineer should be approached in this way than the doctor or lawyer, and it will not be until the engineer has a full sense of his professional dignity and of the value of ethics in his profession that it will be recognized and respected as other professions are.

Acknowledgment.—The above is a paper presented June 20 at the 49th annual convention of the American Water Works Association.

Concrete Pavement Over Poor Subgrade at Port Newark, New Jersey

Unusual Design for Paving on Fresh Hydraulic Fill of Clay

By CHESTER MUELLER

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The principal reasons leading to the adoption of an unusual concrete pavement design in Newark, N. J., were:

1.—The character of the subsoil and underlying strata.

2.—The presence of surface water in quantity.

3.—The lack of time, limiting the operations preliminary to paving.

Due to the dearth of adequate and conclusive information on sub-grade preparation and the many advances made in concrete pavement, the developed design is a mixture brewed of theory, experiment, and experience.

History of Paving Site.—The 22,000 sq. yd. of pavement designed to meet the conditions enumerated, were laid in the spring of 1926 at Port Newark, in response to the sudden demand for streets imposed by the rapid port development. A brief history of the paving area, which fronts the ship channel and extends about 1,500 ft. inland, will provide a background for the description to follow.

Originally, the entire area consisted of a flat level expanse of salt meadow at a general elevation of 5 ft. above mean low water. An average tidal range of 4.7 ft. kept the soft, spongy humus habitually moist. In 1917, as part of a development started several years previously, this area was raised to an elevation of about 8.5 ft., using material dredged from Newark Bay. In 1921, additional hydraulic fill was placed to an elevation of about 12 ft. Compaction and settlement of the fill and underlying strata required still more material three years later in order to maintain the elevation of 12 ft. In 1926, there was, on an average, a 9-ft. layer of clay fill the surface of which was at an elevation of 11 ft. above mean low water.

A number of wash borings in the paving site, revealed material clearly defined, but varying in thickness. The bed-rock, about 75 ft. below the surface, is a sedimentary shale of the Triassic formation common to Northern New Jersey. The 50 ft. of material (clay and sand) immediately above it, is part of the post-glacial drift. Next above this is a 10-ft. layer of mud and silt deposited by the waters entering the vast lake or bay once covering the area. Topping this layer is 5 ft. of humus, the result of the growth and decay of centuries of salt-marsh vegetation. This original soil is now covered by an average 9-ft. layer of dense red clay, hydraulically placed. Possessing all the disqualifications of clay as a sub-base, this upper layer presents the principal problem for successful road construction. A secondary, but no less important, consideration is the plasticity of the layers just beneath.

Observations and Tests on Sub-Grade.—Some observations that directly or indirectly throw light on the character of the soil and sub-grade were made.

Water Content.—When the dredged material was pumped in, two features were noticeable. In the first place, most of the material was in a finely divided state held in suspension by the water, causing the fill to resemble a quicksand for months, or until the drying out was complete. In the second place, numerous rounded masses, "balled clay," came through the pipe line. On examination, the cores of these masses were found to be perfectly dry. These features in themselves are not unusual in dredging experience, but they typify the impermeability of the clay fill.

After the fill had dried out, it was hard, compact, and apparently impervious to water. A rainfall, however, converted the area into a veritable sea of mud, causing water to stand for some time and softening the soil thus immersed to a depth of from 6 to 12 in. Run-off and evaporation disposed of most of the water, restoring, in time, the former hard, dry condition. These alternate conditions of high and low moisture content, resulted in a considerable change in volume as was evidenced by the cracks formed in the drying out process. These "sun cracks" varied in width and depth, depending on the penetration of the surface water and on climatic conditions. Cracks, 1 in. wide and 8 in. deep, dividing the surface into numerous small polygons, were not uncommon.

It would appear, therefore, that little percolation, if any, takes place and that the ground-water level is not influenced by surface water. However, after a rainy period, a trench only 3 ft. deep shows seepage, whereas, in dry periods, 5 or 6 ft. may be excavated before ground-water is encountered. The water content of the soil, then, is affected to considerable depths by rain and melting snow and ice.

Behavior of Piles.—Two influences operate to make the soil unstable, the moisture which softens the surface layer and the plasticity of the under layers. For all building construction in the Port Newark area, pile foundations are required.

To attain a bearing value of 16 tons, it has been found that the average pile must be driven to about 18 ft. below mean low water. However, a wide range from this average is experienced. Numerous pile-driving tests have been made, but thus far no method has been found to predict the pile lengths required for the sites within the area. The minimum penetration may be to 12 ft. below mean low water in one place, while not more than 20 ft. distant, a maximum depth of 32 ft. will be necessary to reach solid bearing. Pile-bearing value is largely dependent on skin friction, yet from the road builders' standpoint these values suggest that the strata beneath vary to such an extent in thickness, moisture content, and physical composition, that they influence the surface stability even for light loading.

Results of Bearing Tests.—In an endeavor to determine just what reliance could be placed on the light load-carrying capacity of the soil, two bearing tests were made. These consisted in preparing a shallow excavation with a level bottom upon which several layers of railroad ties were laid, imposing an equally distributed load over 17 sq. ft.

Elevations were taken, as the initial loading was applied, at each of the four corners of the platform. A week later the load was almost doubled, and

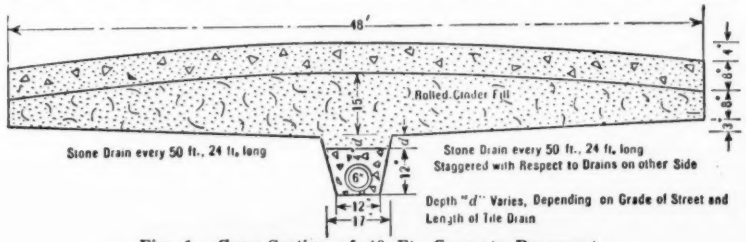
48'
Rolled Cinder Fill
Stone Drain every 50 ft., 24 ft. long
Stone Drain every 50 ft., 24 ft. long
Staggered with Respect to Drains on other Side
Depth "d" Varies, Depending on Grade of Street and
Length of Tile Drain
12
17

Fig. 1.—Cross-Section of 48 Ft. Concrete Pavement

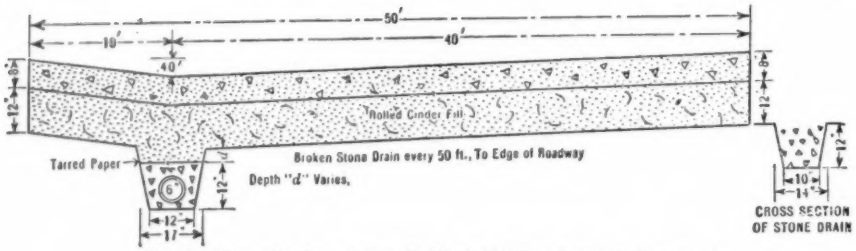

Fig. 2.—Cross-Section of One-Half of 100 Ft. Concrete Pavement

for a period of three weeks, observations were made to determine the settlement. In brief, the results of one test showed that a load of 174 lb. per sq. ft. caused an immediate net settlement of 0.008 ft. at the center; but despite the care taken to apply and distribute the loading equally, one edge of the platform had been raised and the other lowered.

After continuing to add to the load until 352 lb. per sq. ft. had been reached, the total settlement at the center amounted to 0.039 ft. When a week later a loading of 652 lb. per sq. ft. was reached, the settlement had become 0.172 ft. Without the application of further loading the platform settled progressively until at the expiration of the test period, of four weeks, a total settlement of 0.185 was noted. Meanwhile, the behavior of the corners demonstrated that even over 17 sq. ft. inequalities in soil-supporting power existed. In part, this was caused by the effect of moisture in softening the soil under the platform. During the test period, 2.14 in. of rain fell, the times of the heaviest precipitations being marked by the irregular settlement of the corners.

Soil Movements.—The movement of the top few inches of the clay, merely indicated by this test, was conclusively shown when cuts were made through a 3-ft. cinder railroad embankment placed on the clay fill. The clay surface under the center line of the track was depressed 6 to 18 in. and under the edges of the ties, 4 to 8 in., while outside the toes of the slopes it was forced upward 4 to 8 in. The extent of this movement was cumulative; that is, the deeper the clay depression became, the greater the volume of surface water collected and the more penetrating the moisture. Using the field test methods advocated by A. C. Rose,* Assoc. M. Am. Soc. C. E., the moisture equivalent of the subsoil was found to average about 50 per cent and the linear shrinkage, 7 per cent.

The influence of each of the two plastic layers just beneath the fill, was distinct. The meadow strata are very elastic and act as a cushion upon which the clay fill rests. Application of a light load to a sample of this spongy material results in considerable compression and a release of pressure causes almost complete restoration of volume. Filling over this layer compresses it as much as 5 ft. in places and slight additional settlement may occur for several years. The mud and silt layer, being in a semi-fluid condition, tends to flow in the direction of least resistance. The effect of this layer is to equalize pressures imposed on it. On a large visible scale this equalization occurred during the placing of the hydraulic fill. As the material rose in back of the bulkhead, acres of bay bottom, for ¼ mile, or more, seaward (formerly 2 and 3 ft. under water), emerged. This influence on surface structures cannot be disregarded, particularly when they are adjacent to the ship channel or bay front where the mud and silt layer is less confined. Imposition or removal of heavy concentrated ground loading, or the variable water loading due to tides, may operate, through this semi-fluid layer, to set up stresses in the clay crust.

Conclusions for Sub-Grade Study.—The foregoing studies and observations revealed so many indeterminate factors that a positive design, based on the usual assumptions, seemed impossible. The principal sub-grade factors that influence a pavement may be analyzed, however, and listed according to cause, effect, and remedy, as follows:

I.—Presence of Moisture in Clay Subsoil:
- (*A*) Cause:
  - 1.—Physical properties inherent in soil, such as,
    - (*a*) High moisture equivalent; and
    - (*b*) Finely divided condition.
  - 2.—Capillarity plus low elevation above sea level.
  - 3.—Long standing surface water, due to,
    - (*a*) Impermeability of soil; and,
    - (*b*) Irregular contour of surface.
  - 4.—Uniform strata of clay unbroken by veins or by adjoining strata of more permeable material.
- (*B*) Effect:
  - 1.—Lessened, variable, and uncertain bearing power due to plasticity.
  - 2.—Changes of volume due to excessive shrinkage.
  - 3.—Frost action.
  - 4.—Lateral movement of the topsoil on application of the loading.
- (*C*) Remedy:
  - 1.—Draining off the surface water.
  - 2.—Use of layer of fine granular material to:
    - (*a*) Decrease the height of capillary moisture;
    - (*b*) Quickly remove water from surface; and,
    - (*c*) "Cushion" the effect of frost "heaving."
  - 3.—Distribution of the loading over large areas.

II.—Movement of Sub-Grade Soil Layers:
- (*A*) Cause:
  - 1.—Additional compression of the meadow layer due to the added loading.
  - 2.—Further consolidation of the clay fill.
  - 3.—Equalization of pressures due to,
    - (*a*) Weight of tidal prism;
    - (*b*) Variation in the loading and of the surface.
    - (*c*) Deep excavations into the mud and silt layers.
  - 4.—Inequalities in the thickness of the layers.
- (*B*) Effect:
  - 1.—Permanent settlement.
  - 2.—Variable vertical movements.
  - 3.—Upheaval of the clay crust at planes of weakness.
- (*C*) Remedy:
  - 1.—Pile foundation for the pavement.
  - 2.—Use of substantial large sized paving units which would remain intact and keep their "riding qualities" while undergoing displacement due to subgrade movements.

Lessons From Existing Pavement.—In 1925 the construction and maintenance of roads and streets at Port Newark was transferred from the Bureau of Docks to the Bureau of Streets. At this time the only street in the south side area was a 36-ft. granite block pavement, 1,400 ft. long, laid in the spring of 1924.

This roadway consisted of 4 by 5 by 10-in. blocks laid on a 1-in. sand-cement cushion with joints of asphalt and sand, all on a 6-in., reinforced, 1:2.5:5, Portland cement foundation. Naturally, before the design and construction of additional streets, considerable study was given this one.

The base was reinforced with ⅝-in., deformed, square rods, on 6-in. centers transversely and 20-in. centers longitudinally, placed 2 in. above the bottom of the concrete. The pavement was laid on a 0.33 per cent grade and to a 4-in. crown, with one edge on the center line of the proposed 72-ft. width, the curb being about level with the surrounding ground. A depth of about 12 in. was excavated to provide for a layer of steam cinders. No particular grading or shaping of the clay under-grade was attempted, the spring rains creating a

*Proceedings, Am. Soc. C. E., January, 1928, Papers and Discussions, pp. 125 and 132.

deep layer of mud upon which cinders were placed and compacted as rapidly as excavation progressed. The result was a layer of cinders, 6 to 18 in. deep, spread and compacted over an irregular clay surface. No under-drains were placed.

Considering the subsoil drainage feature only, complete neutralization of the poor sub-grade was not accomplished. While it has been quite recently stated that "a poor sub-grade material can be transferred into a good sub-grade by the addition of sufficiently fine granular material or by the use of a layer of suitable granular material,"† this alone does not appear to effect the desired transformation at Port Newark.

It is true, the cinder course permits rapid percolation, keeps capillary water low, and acts as a cushion between the pavement and the volumetric and frost movements of the sub-grade; yet its efficiency is partly destroyed by the irregular contour of the under-base. Thus, when the clay sub-grade is recessed for the pavement, water will graitate to this trench and remain there, giving rise to lateral soil movement as found beneath the 3-ft. railroad cinder embankment previously mentioned. Irregularities of the clay, forming water-pockets, will aggravate the condition. Where a sufficient area is thus weakened beyond the ability of the concrete base to sustain the surface loading, failure might be expected. Examination of the pavement indicates that this may have occurred. The surface has many crosswise waves, the close spacing of the transverse reinforcing rods having doubtlessly prevented even more serious dish-shaped depressions. A more happy choice of reinforcing bar design might have still further aided in resisting the sub-grade forces.

As bearing out the assertion that sub-grade movements affect a pavement (equalization of pressure and other causes being ascribed), a comparison of elevations taken immediately after paving with similar readings taken in 1925, shows that, in general, a settlement (as much as 12 in. in some places) has occurred. A short section revealing a slight rise along one side and the irregular settlement over sections (as distinguished from localized areas), indicates the variable effect of sub-grade movements.

The relation between the location of such pavement movements and the many warehouses and other surface loadings has not been investigated. The fact that all buildings were erected subsequent to paving is, however, a starting point for such an investigation.

Under-Drains and Their Effect.—In the spring of 1926, when paving became necessary, the same conditions as existed for the 1924 paving were present, namely, a saturated top surface of clay, and standing surface water due to frequent rains. Two types of under-drains were used—a single arterial line in the center with laterals, for pavements of less than 50 ft. in width (Fig. 1); and a double arterial line, one under each gutter, with laterals, for pavements of greater width (Fig. 2). The arterial lines are 6-in. tile-drains (none extends more than 400 ft. before

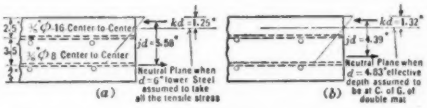
16 Center to Center
8 Center to Center
kd = 1.25"
jd = 3.58"
Neutral Plane when d = 6" lower Steel assumed to take all the tensile stress
(a)
kd = 1.32"
jd = 4.39"
Neutral Plane when d = 4.83" effective depth assumed to be at C. of G. of double mat
(b)

Fig. 3.—Analysis of Reinforced Concrete Longitudinal Pavement Section

entering a surface-water catch-basin or open ditch) laid to a 0.50 per cent minimum grade, recessed in the clay under-grade, and completely surrounded by broken stone. Tees are placed every 50 ft. from which broken-stone drains through the clay run out to the edge of the pavement. Tarred paper around joints, between the cinders and the broken stone, and other features common to such construction were included. In addition to the tile and stone drains, the clay under-grade was carefully shaped to direct water toward the arterial drains.

The value of these under-drains first showed itself when a dry clay under-grade was obtained upon which a layer of cinders could be carefully laid and compacted in place. After a pavement is laid their value is, of course, not so apparent. In view of the paradoxical results as to moisture content obtained under drained and under-drained sections of the Bates Test Road,‡ it might appear that tile drains fail to live up to expectations. The common assumption is that a tile pipe will drain a width of about six times its depth in clay soils, and fifteen to twenty times its depth in porous soils. When this assumption is made the fact that "time" is an important element is generally overlooked — particularly where clay soils are concerned; for, if drainage becomes operative only on saturation of the clay, then its value is nil. On the other hand, if a rate of flow through the soil is established shortly after the surface is wetted, then the system has merit.

Field studies would best determine the behavior of water on passage through a clay subsoil. However, as an index to what may occur, the experience of the writer in making the moisture equivalent tests will serve. Samples of the subsoil were gathered. While obviously the clay contained moisture, the masses were hard to break up and no dampness was visible; not even did the paper on which the samples were laid, become moistened. So little water was added to produce a "shiny" surface on the test samples of the clay that the writer decided to dry out the unused portions of several samples and thus, by weight, determine what moisture was originally present. The results showed that each sample in its original state contained about 20 per cent of water. If a mass of 25 lb. of such clay can be removed from the ground and exposed without drying out, it is evident that the most closely spaced tile drains will likewise fail to remove the moisture. While from the appearance of the clay this condition did not affect its bearing power, yet, evidently, much more moisture would accumulate before "seepage" or drainage would begin.

Assuming, then, that the tile and stone drains are ineffective in themselves in draining water through clay, they still are important in removing the water brought to them by the sloping clay under-surface. To recapitulate:

1.—The porous cinder layer rapidly removes water from beneath the pavement;

2.—This is added by the herring-bone under-drainage system; and

3.—Water otherwise saturating the clay to disintegration is drained, as surface water, into the "broken-stone gutters."

Concrete Pavement Provided.—Consideration of various types of pavement finally led to the selection of concrete as best suited to the sub-grade conditions at Port Newark. The developed design consists of a 1:1.5:3 portland cement, reinforced, concrete pavement laid to a uniform thickness of 8 in. The double mat reinforcement is composed of ⅜-in. deformed round bars assembled so that the lower mat is supported 2 in. above the bottom of the pavement and the upper mat is separated therefrom by 3½ in. The lower members are spaced 8 in., both transversely and longitudinally; the upper transverse bars are on 8-in. centers, while the longitudinal bars are on 16-in. centers. The reinforcement extends to within 2 to 6 in. from the edges of the slabs, adjacent mats being properly lapped and the other usual practices observed.

All joints are vertical, with ¾-in. dowel-pins connecting the slabs across transverse joints. At all slab corners and angles, ⅜-in. bars, 6 ft. long, were bent outward in the form of a **U** (sides at an angle of 22 deg.) and placed in the top mat to combat corner failures. The specifications under which the work was performed, embody many of the proposals advanced by the committees on concrete pavement specifications of various technical societies. Daily laboratory tests checked the quality of the materials used and the strength of the resulting product. In

†"Recent Conclusions in Highway Research," by A. T. Goldbeck, Assoc. M. Am. Soc. C. E., Roads and Streets, March, 1925, p. 458.

‡"Tentative Conclusions on Design of Concrete Surfaces," by Clifford Older, M. Am. Soc. C. E., Roads and Streets, May, 1924.

the field, the slump test was used to control the consistency of the mix.

In scrutinizing any concrete pavement design, examination in the light of recent investigation is desirable. Each feature of this design will be so considered.

The 1:1.5:3 mix, with trap rock as the coarse aggregate, appears to represent the greatest strength and the least variability for road-building purposes. Accelerated wear tests conducted by the U. S. Bureau of Public Roads reveal that a 1:1.5 mortar with trap-rock aggregate provides one of the most resistant surfaces to abrasion.§ It is particularly fitting that this mix be used at Port Newark where heavy trucking is the principal class of traffic.

Students of recent development in design will be inclined, no doubt, to view a uniform thickness as a less advanced feature than the remainder of the design. It is usually assumed that a wheel load 3 ft. from the pavement's edge will do no damage. This being the condition at Port Newark, there is no reason for increasing the thickness of these pavements. Traffic is inclined to avoid the edge (on the 100-ft. streets) due to the depressed gutter lines, and likewise on the 48-ft. streets, due to the adjacent poles or other like features.

Recent studies¶ made public by the Highway Research Board of National Research Council, show that by increasing the reinforcement, a reduction in cracks is obtained more economically than by increasing the concrete thickness. Specifically, 170 lb. of bar reinforcement per 100 sq. ft. (50 per cent each way) causes a reduction in combined transverse and longitudinal cracks equal to an added 2-in. center thickness of concrete. In the design used at Port Newark there is 169 lb. of reinforcement symmetrically placed, the added alternate transverse bars in the upper mat making the total reinforcement 198 lb. per 100 sq. ft. It would follow, then, that the effectiveness of at least 2 in. of added concrete is obtained with respect to crack reduction.

Furthermore, the report states, for equal weights of reinforcement small bars closely spaced are more effective in minimizing crack development than larger bars. At Port Newark with ⅜-in. bars, 8 in. apart, it is hoped that a proper distribution has been achieved.

A pavement slab design cannot be analyzed with as great a degree of certainty as the usual floor-slab, yet there are reasons why the same kind of an analysis may be applied. It may be desirable, for example, in a comparative study, or in determining the capacity of the slab to bridge newly back-filled utility trenches; or as in the present case, in indicating the extent to which sub-grade failures will be harmless and in suggesting the possible piling required where total sub-grade failure is expected.

Computation of Strength. — Where only occasional sub-grade failures are expected, pavement slabs are not designed to carry their loads entirely unsupported since such a course would be both extravagant and unjustified. At Port Newark, localized areas of non-support might possibly occur due to partial disruption of the drainage system or minor settlements attendant on the movement of the underlying strata. When such areas do occur, the worst possible condition will not be 36-ft. slab supported at its ends only, since such a condition would pre-suppose exceptionally high bearing value for the sub-grade immediately adjacent to the "failure" and the ability of the dowel-pins to withstand the resulting shear. Instead, some indeterminate lesser area of non-support will generally develop, and then the slab, as a unit, will settle to a new bearing. Impact, inertia of the slab, and the many other factors, however, may operate to cause failure of the slab before it can adapt itself to the new plane of support.

As pavement slabs are used for years following their initial failure and as so many variable and uncertain elements preclude an accurate mathematical analysis, it is not so much the "safe" carrying capacity, but the ultimate carrying capacity, that is desired. For this purpose it is proposed to use 1,500 lb. per sq. in. as the "yield point"** of the 1:1.5:3 concrete; 40,000 lb. per sq. in. as the yield point of the steel; and $n = 12$.

Taking a longitudinal section of the slab, 8 in. wide, and analyzing it as a continuous beam by straight-line formulas,†† and neglecting for the present the upper mat (Fig. 3(a)):

a_s=0.1105 sq. in.
p=0.0023
k=0.2089
j=0.9304
kd=1.25 in.
jd=5.58 in.
M_s=24 643 in-lb.
f_c=880 lb. per sq. in.

An examination of Fig. 3 shows that the upper steel falls below the neutral plane.

Treating the entire steel system as taking the tensile stress in the beam at a depth equal to the distance of its effective center of gravity below the surface (Fig. 3 (b)), then

d=4.83
a_s=0.1658
p=0.00429
pn=0.05148
k=0.273
j=0.909
kd=1.32 in. (or 1.18 in. above the top steel).
jd=4.39 in.

$$M_s = 27\,370 \text{ in-lb.} = \frac{27\,370}{12} \text{ ft-lb.}$$

f_c=1 260 lb. per sq. in.

Using $M = \frac{w l^2}{12}$ as for a continuous beam,

$$\frac{w l^2}{12} = \frac{27\,370}{12}$$

or,

$$w l^2 = 27\,370$$

Then, if, w=500 lb. per sq. ft.=333 lb. per running ft.,

or,

$$l^2 = 82$$

$$l = 9 \text{ ft.}$$

Thus, a load of 400 lb. per sq. ft. in addition to the weight of the slab may cause failure due to bending stresses when the unsupported area has a width equal to that of the slab and a length of 9 ft. The analysis of a transverse section in a like manner will reveal a greater resistance to failure because of the additional steel in the top mat. A cursory examination shows that a concentrated wheel load of 7 tons will probably cause failure of the slab over an unsupported area the width of the slab and about 4 or 5 ft. long.

Where negative bending moments occur, the top steel should take the tensile stresses in the upper part of the slab. Failure under such a load will be perhaps more frequent (due to the position of the steel below the surface) than that caused by a positive moment.

When it is considered that the deflection of a slab under loading may add sub-grade support, and that with a smooth concrete surface, impact is kept at a minimum, the Port Newark slabs may be said to possess a relatively high resistance to failure—but should failure occur, a separation into rather large square sections will result, with the steel stressed beyond its yeild point, but still linking the sections together.

If a pile foundation is adopted to replace efforts at under-drainage, it will be necessary to re-design the slabs, decreasing the size and increasing the reinforcement in order to transfer the surface loading to the piles. Use of 6 by 7-ft. slabs, 8 in. deep, with about 270 lb. of steel per 100 sq. ft. and rows of 30-ft. piles, 8 to a "bent," with the bents 6 ft. apart, might be the principal elements of a possible design adopted. Whether the use of the Compressol System would be as suitable and more economical has not been investigated as yet by the Newark Bureau of Streets.

Comparison of Paving Costs.—Itemizing the approximate actual cost per square yard of both types of pavement and under-drainage laid at Port Newark, and estimating the probable cost of a pile-supported pavement, the results are as follows:

Granite Block (Actual Cost):	
Pavement on 6-in. concrete base (including 6 in. of excavation)	$ 7.38
Reinforcement (about 31 lb.)	1.40
Excavation (average)	0.70
Cinder fill (average)	0.90
Average cost per square yard	$10.38
Reinforced Concrete (Most Recent of the Three Contracts Let):	
Pavement complete	$ 3.57
Excavation (average)	0.84
Cinder fill (average)	1.60
Tile-drain (average)	0.20
Stone-drain (average)	0.40
Average cost per square yard	$ 6.61

§"Researches on the Structural Design of Highways, by the United States Bureau of Public Roads," by A. T. Goldbeck, Assoc. M. Am. Soc. C. E., Transactions, Am. Soc. C. E. Vol. 88 (1925), p. 264.

¶Report, Highway Research Board, National Research Council, Vol. II, 1926, p. 12.

**See Bulletin No. 5, Structural Materials Research Laboratory, Lewis Inst., Chicago, Ill.

††Symbols and analysis follow the Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, Proceedings, Am. Soc. C. E., October, 1924, Papers and Discussions, p. 1153.

Pile-Supported Pavement (Estimated Cost):	
Pavement slab	$ 4.50
Pile foundation	7.00
Cinder fill	1.60
Excavation	0.80
Average cost per square yard	$13.90

Leaving aside the cost of surface drainage, gutter curbing, etc., the reinforced concrete pavement used at Port Newark appears to be the more economical in comparison with the granite block, and the more likely to prove satisfactory. Should it prove to deteriorate rapidly, the more than twice as expensive pile-supported pavement may receive serious consideration as a substitute.

Results to Date.—As the pavement is of comparatively recent construction, no time-proven conclusions as to its effectiveness can be drawn. However, interesting observations have been made.

Sub-grade movement has occured and displaced the pavement, noticeably, at three locations. In all cases it is at slab junctions and has in no wise affected the integrity of the slabs. At the maximum depression, water 4 in. deep is pocketed. Since numerous track crossings prevented the adoption of steeper grades, relatively slight slab settlement causes these water pockets to form.

Examination of the tile-drain outlets during rains shows them to be carrying a considerable volume of water during and after such periods. What settlement has occured is believed to be due to the major movements of the under-grade layers and not to movements arising from moisture-laden subsoil. Check elevations recently taken over the pavement substantiates this belief in revealing, over considerable areas, elevations differing from those to which the concrete was originally laid. The ability of the slabs to withstand displacement of this character or adopt themselves to it, while under traffic, seems, thus far, to justify the design used.

Conclusion.—At present, considerable study is being given to subsoil problems. As heretofore, the actual service experiences will apply the final test to the various solutions advanced and will point the way to still further improvements. Where a more or less experimental or novel design is used, it is believed an account of the surrounding circumstances will be of interest to engineers confronted with similar subgrade conditions. No claim is made that the Port Newark pavement is the best design possible nor that it is entirely original, since the experience of others in the highway construction field has been freely drawn upon; but it is one in which the City of Newark reposed sufficient confidence to expand $148,000.

Acknowledgment.—The foregoing is taken from the Proceedings of the American Society of Civil Engineers.

Hydraulic Gradient

Its Use in Water Works Maintenance

By ELMER G. HOOPER
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THE hydraulic gradient is a most useful and singularly successful means for solving certain kinds of problems that come up in maintenance, but it is necessary to recognize its limitations in order to retain full confidence in it. I shall try to demonstrate by example later on in this paper the type of problem that may be readily handled and show how in one or two cases the method had to be supplemented by other means to complete the solution. First, however, I will ask you to bear with me while I go into hydraulic theory a little and try to interpret it in a way that is useful to the practicing water works man. Some of you may be bored because I am telling you something you already know, but I am sure there are others who have forgotten enough of it to make it worth while to refresh your memories.

The Hydraulic Gradient Theory.—The "Hydraulic Gradient" may be defined as a continuous line or connected series of lines following the horizontal meanderings of the pipe or conduit but at a distance above or below it equal to the height to which the water from it would rise due to pressure in the main, either positive or negative. In other words it represents the limit of height to which water from the main could be delivered at any point. A sloping gradient indicates flow; a sudden drop in a sloping gradient at any point indicates concentrated loss of head, as at a partially closed gate, an obstruction, or a change in diameter of pipe section if the gradient has a different slope following the drop. A gradient changing suddenly from a steep slope to a less slope without change of pipe diameter usually means a large concentrated outflow at the point of gradient change, though it may mean a flow from a very old pipe into a new pipe of the same diameter. A horizontal gradient indicates no flow or very little; when a flat gradient drops suddenly at a point and resumes beyond at a lower level it indicates a disconnection, a gate down or a complete obstruction. In all these the point at which the gradient breaks is the important one. A gradient that slopes too steeply indicates too much flow for that size of pipe or too much deterioration in the pipe to permit that flow; in any case a gradient that is found to be much steeper than it normally is usually means excessive draft, probably leakage.

The mathematical expression for the hydraulic gradient may be obtained by transposing Bernoulli's Theorem, which must be familiar to all who have studied hydraulics in recent years. The theorem may be written in the following form between any two sections of the main:

$$\frac{v_1^2}{2g} + \frac{p_1}{w} + z_1 + h = \frac{v_2^2}{2g} + \frac{p_2}{w} + z_2 + L.H.$$

where v represents velocity at the respective sections,
p represents gauge pressure if w is 0.434,
z represents elevation of the pipe at the respective sections,
h represents lift from pump if there is one between the sections,
$L.H.$ represents the sum of all losses of head between the sections,

and $\frac{v^2}{2g}$ is the height in feet to which the water would rise due to velocity alone; $\frac{p}{w}$ is the height to which the water would rise due to pressure alone if an open vertical tube were inserted in the pipe (the height of the gradient above the pipe at the point); z is the height of the section of pipe above a common datun; the losses of head are divided for convenience into those due to friction in pipe of uniform diameter, to bends, to expansions and to contractions of sections, and then summed up. If a common level or datun is used it may be seen that the term $(\frac{p}{w} + z)$ is the height of the gradient at the section above that common level, and that $(\frac{p_1}{w} + z_1) - (\frac{p_2}{w} + z_2)$ is the drop of the gradient betwen the two sections. If we transpose Bernoulli's equation to produce this form we will have the following:

$$\left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} + L.H. - h$$

meaning that the gradient drops due to loss of head, rises due to lift of the pump, drops if the velocity increases and rises if the velocity decreases. For practical water works purposes outside the pumping station all items except loss of head may be neglected and we may say then that the drop in the gradient is from loss of head. The drop in the gradient is therefore a measure of the efficiency of the parts of the system, and the nature and magnitude of the drop may be interpreted to tell whether anything is wrong, and may indicate what and where.

Application of the Gradient to Practice.—To illustrate the application of the gradient to practice, I am drawing on my memory of experiences in the service of the Department of Water Supply, Gas and Electricity, New York City, and because of the ten years or more that have elapsed since that service only a few outstanding examples are clear enough in my mind to

present them. As the cases are described you will no doubt say to yourselves, "why, he is only taking pressures." I shall fully agree with you, for it is the pressure reading converted to feet head and added to the hydrant elevation that gives the gradient elevation. You will appreciate then that it is only a common, everyday job that can be put to very useful ends when properly interpreted.

Case 1: An abnormally steep gradient, indicating excessive flow on a 12-in. main in 43rd St., Manhattan, between 5th and Madison Ave. A casual pressure taken on a hydrant on the north side of 43rd St., east of Madison Ave. seemed to be much lower than the district should have and this was verified as fact by pressures taken on mains in the same service not closely connected to the one suspected. This latter main had no connections to any other mains at or near Madison Ave. and 43rd St., though had there been any they would have been closed temporarily to permit flow from the two ends only, for the purpose of the investigation. The problem then consisted in determining and analyzing the gradient on a line 12 in. in diameter beginning at a 20-in. trunk main in Fifth Ave., extending east through 43rd St. across Madison Ave., where it changes to 6 in. in diameter continuing east to Vanderbilt Ave. at Grand Central Terminal, then north one block to 44th St. in which it turned west to connect with a 12-in. main in Madison Ave. There is a valve in 43rd St. east of Madison Ave. but west of the hydrant on which the first pressure was taken. This valve, a 12-in., will be designated as valve 1 for future reference. Valve 2, a 6-in., is on 44th St. east of Madison Ave. There were five hydrants on the line at which pressures were taken and converted to feet head. Elevations of these hydrants were determined by hand level readings from the most convenient street intersection whose elevation was known or could be assumed for datum, and the spacing of the hydrants was measured by pacing. By adding the pressure head to the elevation for each hydrant and plotting it to scale for the whole line a gradient was found consisting of two sections, each having a fairly steep slope downward from the ends of the main toward a common point about on the east building line of Madison Ave. and 43d St., near valve 1. In order to find on which side of this valve the outflow occurred, it was closed so that the supply could come from only one direction. The hydrant pressure dropped to less than zero, showing that the flow was from the east through the 6-in. line to a point just east of the valve, and that the amount of outflow was equal to the capacity of that line at least. For checking the location of the outflow and to obtain data to compute the amount, valve 1 was opened and 2 was closed and simultaneous pressures were taken for a new gradient.

Investigation showed that Grand Central Terminal improvements extended under the block from Vanderbilt to Madison Ave. east building line; that the main dropped several feet to pass between the floor of the basement and the ceiling of the sub-basement; that a 6-in. blow-off had been installed and connected with the sewer at that level in the west wall of the basement; that a special operating wrench for the blow-off gate had had to be provided; and that finally this gate was wide open thereby filling the sewer, a large one, more than two-thirds full. It was estimated from the pipe size and loss of head that about 4 m.g.d. was wasted and the sewer marks indicated it had been doing so a long time.

Another example quite similar to the above, except that it was on a submarine line, was taken as the subject of a brief paper read before a meeting of the New England Water Works Association in 1916.

Case 2: Gradient slightly lower than normal on a trunk main where pressure variation was usually slight; pressure reading was only about a pound lower than normal on a hydrant from a 20-in. main a few hundred feet east of its connection with a 48-in. main. This was on Pelham Parkway east of Southern Boulevard, the Bronx, on a main leading about 6 miles to City Island, having two 12-in. and one 8-in. lines at intermediate points normally feeding out toward Westchester village. When the gate was closed on first 12-in. feeder the gradient showed that the flow had been into the 20-in. main; the same thing was indicated at the other two lines showing a heavy draft toward City Island. At two points the 20-in. line divided into two 12-in. lines for under water crossings and the closing of these in succession affected the gradient in such a way as to show the supposed trouble to be still farther ahead and the gradient was becoming noticeably lower and lower. The heavy flow was finally pinned down to an 8-in. under water line about a mile long, which together with a 12-in. line supplied Hart's Island with water. When this crossing was shut off the local pressures went up from about 25 to over 40 lb. The slope of the gradient was used to determine the approximate location of the leak and by using a boat, which acted as a good aquaphone, the location was checked and buoyed for the repair crew. This leak or series of leaks (three lengths of split pipe not far from each other) was under 16 ft. of water at low tide. Less than a day was consumed from the time the suspicion was first aroused until the trouble was located, and for the most part by hydraulic gradient.

Case 3: Flat gradient followed by sudden drop. On one of the early days of 1917 when troops were being assembled and trained at Fort Schuyler, N. Y., water was suddenly cut off from the post. After considerable delay and late in the day word of the trouble was received. From the story of those on the ground the easiest and most obvious thing to produce results seemed to be pressure readings on hydrants outside the reservation since it was known there was no pressure within. The first reading taken showed a pressure slightly above normal, indicating at once a plugging of the line. Further investigation discovered a 6-in. meter with a strainer just inside the reservation and a very large eel tightly squeezed into the strainer thereby shutting off the entire supply. The trouble was located in about a half hour and remedied in another hour.

Another somewhat similar procedure discovered a rather unique plug in a section of 6-in. water line at 140th St. and East River which connects with an under water line to North Brother's Island. About 50 ft. of fire hose without couplings and tightly folded into the pipe by unbalanced pressure, produced by its own resistance to movement, completely shut off the supply of water to the island from the Bronx mainland, leaving the island dependent on another submarine line to Riker's Island and the mainland beyond. This was discovered when investigating the adequacy of fire protection for the island. The reason for the hose being in the pipe was learned later, but it would take too long to tell it here.

Under this case also would come the examples of gates closed and of pipes cut and capped. Such conditions were met with a number of times and it was not possible in any of the cases to tell which of the two were responsible until an excavation and an examination had been made. Because this was not an unusual or startling condition no particular one stands out in mind sufficiently clearly to be reproduced.

In the preceding paragraphs enough of both theory and of practice has been presented to provide food for reflection and it is to be hoped that some new and workable ideas have been suggested to some of you who have had the patience and the kindness to listen.

Acknowledgment.—The above is an abstract of a paper presented May 3 before the New York Section of the American Water Works Association.

Methods of Thawing Frozen Hydrants

According to a study of the methods used for thawing out frozen hydrants made by the New York State Bureau of Municipal Information, 25 municipalities use steam for this purpose, ten use electricity, seven use a commercial hydrant-thawing device, and five use salt, carbide or other materials. Two municipalities use alcohol in the hydrants to prevent freezing, and fourteen reported that they never experienced any difficulty with the freezing of hydrants.

Removal of Iron From Hard Ground Waters

Occurrence, Effects and Methods and Costs of Treatment

By R. L. McNAMEE

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IRON is found in solution in the ground waters of glaciated regions of the Middle West as ferrous carbonate. The soils contain iron as the ferric oxide (Fe_2O_3). Ground waters, especially in deeper strata, reduce the iron to the ferrous oxide (FeO). Carbon dioxide, common in hard waters, combines with the oxide to form ferrous carbonate. The ferrous carbonate is relatively stable under conditions such that the carbon dioxide is held in solution and oxidation does not take place. But when these conditions are not maintained and the water is exposed to the air as in open reservoirs or when drawn for use, a natural oxidation takes place and the iron reverts to an insoluble state and settles out or deposits upon many surfaces with which the water comes in contact.

Effect of Iron in Water.—The objectionable qualities of iron-bearing waters are common knowledge in Indiana. Plumbing fixtures become stained a reddish brown color where water drips from faucets. Fabrics acquire a yellowish discoloration in the laundering process. Certain industries find it necessary to eliminate the iron before using it. Under some conditions, dyes cannot be applied with waters having iron in solution. Woolens in the process of fabrication are discolored in washing. In the kitchen, also, iron has undesirable effects. Under some conditions it is impossible to brew tea of satisfactory taste. Certain vegetables assume disagreeable flavors when cooked in iron-bearing waters. When the Crenothrix is present, unpleasant tastes and odors are often present in the tap water.

These conditions, or some of them, are noticeable generally when the iron content exceeds 0.5 p.p.m. The United States Treasury Department Standard for drinking waters for use on common carriers in interstate traffic provides that the iron should not exceed 0.3 p.p.m.

Method of Treatment.—The artificial means of treatment employed to remove iron are substantially the same in principle as those natural processes which cause the precipitation and deposition of iron at the point of use. The treatment generally consists of three processes in series: aeration, sedimentation and filtration. Under certain conditions treatment with a coagulant is necessary in order to secure effective sedimentation. The aeration is the means by which the iron is chemically changed from the soluble to the insoluble form. The sedimentation is the means by which part of this insoluble iron is separated from the water. Some of it is in such a finely divided state that it will not settle within reasonable length of time, for which sedimentation basins may be provided. Filtration through sand is utilized to remove these finer sediments, for which purpose it has come to be an essential element of the treatment.

The removal of iron is not always so simple as this statement of procedure may indicate. The problem varies with the chemical content of the water and is seriously complicated with waters high in organic matter or bearing manganese in considerable amount.

Aeration.—The aeration of water is usually accomplished by the exposure of the water to the atmosphere under conditions favorable for its absorption. In a few instances, aeration has been provided by forcing air through the water by means of grids of perforated pipes or diffusers placed at the bottom of tanks through which the water passes. Aeration by such means is provided, incidentally, by the air lift pump, for which purpose this type of pumping equipment is to be preferred for iron bearing ground waters in some cases, over other types. Of all its applications the air lift pump is, of course, best suited to raising water from wells.

A variety of devices have been developed and are being used to facilitate the exposure of water to the atmosphere for purposes of aeration. Essentially they may be classed in three groups: sprays, falls, and contact trays. In many plants, a combination of two or more devices is employed.

Sprays are of several types, from simple orifices in pipes to more complicated whirling nozzles similar to those used for lawn sprinkling. An unique and efficient spray nozzle is that developed for use at the Sacramento water purification plant. The nozzle proper is formed as a bell-mouth facing upward. The throttling is secured by means of a conical casting which is floated by the head of water and which deflects the stream into a thin sheet over a wide radius. It operates well under considerable variations of head.

Sprays of one type or another are employed for aeration at Amesbury, Mass., Griffin, Ga., Lawrence, Kan., Leroy, O., Long Beach, N. Y., Middleboro, Mass., Selma, Ala., Stuart, Fla., and Wadsworth, O. The plant now under construction at LaPorte, Ind., will use sprays of the Sacramento type.

Falls in their simplest form consist of riffles, sloping surfaces sometimes provided with low baffles or ridges, over which the water flows in a thin sheet and thus exposes a large surface to the air. This type has the advantage of a low head loss but requires a comparatively large area. Some plants use a series of steps so arranged that the water has a free fall of about a foot between steps. This type requires more head than the riffles, but less area and in general will effect better aeration due possibly to the splashing of falls on the succeeding steps. Multiple splash trays are an elaboration of the series of steps. They consist of a number of shallow pans so arranged at levels one below another that the water overflowing the rims of pans on one level is caught on the pans of the next level below. This type secures the benefits of both the thin sheet of the riffles and the free fall and splash of the steps and is more economical of area than either.

Falls of one type or another are employed for aeration at Champaign, Ill., Excelsior Springs, Mo., Garretsville, O., Liberty, Mo., Red Bank, N. J., Sioux Falls, S. D., and Superior, Wis.

Contact trays are commonly built as a series of trays mounted one above another and filled with coke to depths ranging from 3 to 12 in. The water is piped to the uppermost tray and then trickles downward through the coke and drops through slots or perforated openings in the supporting tray to the next lower one. They accomplish aeration by causing the water to spread out over the surface of the material and absorb air which may freely pass through the shallow depth of material.

Contact trays are employed for aera-

Table I.—Reported Efficiencies of Certain Iron Removal Plants in the Middle West

Location	Treatment Processes*	Total Iron Raw p.p.m.	Total Iron Treated p.p.m.	Reference
Benton Harbor, Mich.	C S F	1.0–2.0	0.1†	(1)
Champaign, Ill.	A F	Practically complete removal		(2)
Leroy, O.	A P F	2.0	0.00	(3)
Memphis, Tenn.	A P F	0.60–0.75	0.03	(4)
Shelby, O.	A S F	1.6	0.10	(3)
Sioux Falls, S. D.	A S F	4.0–5.0	0.15	(5)
Wadsworth, O.	A S F	1.4	0.00	(3)
Xenia, O.	A S F	1.4	0.10	(3)

*A, aerators; P, contact beds as prefilters; C, coagulant; S, settling basin; F, sand filters.
†Experimental result.

tion at Liberty, Mo., Lodi, O., Memphis, Tenn., Shelby, O., Wausau, Wis., and Xenia, O.

Coagulation.—In certain cases, the iron, after aeration, seems to exist to a large degree in an extremely finely divided or colloidal state, such that it is very difficult to settle. In such cases, the sedimentation is materially improved by treating the water with some form of coagulant. The agents ordinarily used for this purpose are lime, which also serves to remove the carbon dioxide, or a finely divided clay which seems to benefit sedimentation by a sort of mechanical coagulation. Ordinarily in the middle western states the iron precipitates readily following simple aeration, so that the use of a coagulant is not necessary. The treatment of the water with lime is sometimes used, however, for the removal of carbon dioxide.

Sedimentation.—The separation of a large part of the insoluble iron carbonate resulting from the process of aeration is ordinarily practicable by allowing the water to flow slowly and quietly through basins of ample capacity. In waters containing much organic matter the use of a coagulant is necessary. A detention period of about six hours is usually sufficient to settle out the bulk of the iron sludge. The amount that will not precipitate within this length of time can be more economically removed by filtration.

When used following contact beds, sedimentation performs an important service in catching and settling out the sludge which occasionally sloughs off from the contact medium.

Filtration.—The process of filtration as applied for the removal of iron provides means for the deposition of the insoluble iron upon the surfaces so arranged that they may be cleaned at intervals as necessary. Two principal forms have been employed, contact beds and sand filters.

Contact beds are intended to supply a large surface area over which the water passes and upon which it deposits the insoluble iron particles. Where sufficient aeration is otherwise provided, these beds are not primarily designed to aerate the water. Under some conditions, they are operated submerged with water, a condition that precludes aeration from the atmosphere. In various plants, they serve both functions of aeration and deposition by contact in various relative degrees.

A variety of designs have resulted from the various uses of contact beds. The flow may be either downward or upward. The downward flow bed provides opportunity for aeration, controlled by partial submergence if desired. Upward flow beds must always operate submerged. The contact medium is usually coke but a great variety of materials such as shavings, wooden slats, bricks, and broken stone have been used with success. Provision must be made for flushing out the accumulated iron deposits at intervals. With some contact media, a positive washing arrangement must be provided.

The use of contact beds as a final treatment process is not always satisfactory. With high initial iron content the amount removed is usually high, but this process may leave too great an amount remaining in the effluent. In such cases, they are commonly operated as prefilters, followed by sedimentation and sand filters.

Contact beds are used at Amesbury, Mass., Brookline, Mass., Griffin, Ga., Leroy, O., Lowell, Mass., and Middleboro, Mass.

Sand filters, insofar as their service for the removal of iron is concerned, are simple strainers exposing large contact surfaces to the water. For such purposes alone, they usually remove iron more thoroughly than contact beds. But, in addition to the service in iron removal, the filtration process yields such important benefits in clarification and bacterial removal, that its use is warranted even at the somewhat greater first cost. Sand filters are more easily controlled and less subject to periods of inefficient operation than the contact beds. In general, the design of filters for iron removal is not greatly different from those for other purposes of water purification.

Plants of the following places employ rapid sand filters as a final iron removal process: Benton Harbor, Mich., Champaign, Ill., Freeport, Ill., Griffin, Ga., Iowa City, Ia., Leroy, O., Marshalltown, Ia., Memphis, Tenn., Red Bank, N. J., Selma, Ala., Shelby, O., Sioux Falls, S. D., Wadsworth, O., Wausau, Wis. The plant now under construction at LaPorte, Ind., will use rapid sand filters.

Efficiency of Iron Removal Plants.—A number of iron removal plants in the middle western states treating water generally similar to that from the ground water sources of Indiana are shown in Table I. The treatment processes employed are indicated and the iron content of both the raw water and final effluent is stated as reported by designing engineers or plant operators.

These data indicate that modern well-designed plants employing aeration, sedimentation or prefiltration and final filtration will reduce the iron naturally present in ground waters to amounts that cause no objection. Some of the data given resulted from experimental studies or early operation periods of new plants and it is probable that even better results have been obtained with these plants after they have become well regulated.

Cost of Iron Removal.—It is not possible to determine easily either the average investment cost or the average operating cost of iron removal plants. Variable conditions materially affect the design of plants and the cost of their construction. In many cases, existing works are utilized with considerable saving in new investment.

Table II gives a general idea of the investment usually required for iron removal plants. The data are as reported in current literature. Full details of the structures and equipment covered by these are not stated in all cases.

In all of these plants the filtration is provided by rapid sand filters of modern design which, in addition to their functions in the removal of iron, also clarify the water and eliminate bacterial pollution.

The data indicate that complete iron removal plants, employing the processes of aeration, sedimentation and filtration, and chemical treatment if necessary, will cost from $35,000 to $45,000 per million gallons per day of nominal capacity. Substantial reductions from these figures may often be secured where it is possible to utilize existing basins and structures to advantage.

Acknowledgment.—The above is an abstract of a paper presented at the 1929 convention of the Indiana Section of the American Water Works Association.

Table II.—Approximate Investments Required for Iron Removal Plants

Location	Treatment Processes*	Nominal Capacity m.g.d.‖	Investment in Plant	Investment Per Million Gallons Per Day	Reference
Benton Harbor, Mich.	C S F†	2.0	$199,134	$99,567	(6)
Selma, Ala.	A S F	1.5	65,000	43,333	(7)
Shelby, O.	A S F	1.0	35,000	35,000	(8)
Sioux Falls, S. D.	A S F‡	8.0	89,000	11,125	(5)
Wausau, Wis.	A C S F	3.0	125,000	41,667	(9)
LaPorte, Ind.	A S C S F§	4.0	124,000	31,000	

*A, aerators; P, contact beds as prefilters; C, coagulant; S, settling basin; F, sand filters.
†Includes additional processes for softening which materially increase cost.
‡Existing filtered water reservoir utilized as substructure.
§Existing settling basins utilized, but full capacity not required for iron removal.
‖m.g.d.—million gallons per day.

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Protection of Water Supply Catchment Area

An Interesting Discussion of the Control of Watersheds

By JOHN F. SKINNER
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OUR first thought in connection with a watershed should be "conservation." We must conserve the water which it produces both as to quantity and quality. To do this we should preserve natural conditions, forest conditions and soil conditions, cleanliness and sanitary conditions, and also beauty and public opinion for if we are careful not to mar the landscape and not to make a point of excluding those who may enjoy its recreational aspects we shall go far toward securing cooperation in maintaining the cleanliness which is so much to be desired. To this end the watershed may be made a sanctuary for wild life; unusual types and specimens of trees may be marked, as in a park; roads may be constructed to make the entire territory accessible and recreational features may be stressed or at least allowed under proper regulations.

Sources of Water Supply.—If the water supply is from wells, less attention will be paid to the catchment area. Artesian wells which pass through impervious rocks or clay materials may reach water bearing sands which derive their water from distant sources and the water will be naturally filtered. Wells into limestone which receive through large fissures are often polluted. A study of the geology of the region may disclose the origin of the water and in some cases protection of the catchment area may be valuable. Shallow wells sunk into water bearing sand or gravel require protection in the immediate vicinity of the wells and the water from a greater distance will be naturally filtered.

When a supply is taken from a large stream or lake it will generally be economically inexpedient to attempt to protect the watershed; attention may better be devoted to the location of the intake, to minimizing local pollution and to subsequent treatment of the water.

For surface supplies from sparsely inhibited upland areas, considerable attention may be paid to protective measures and if the property is cheap, large areas may be purchased and controlled. Where the storage is small so that chance contamination may reach the supply quickly, people should be excluded as thoroughly as possible from the watershed; if, on the other hand, there is long storage the public may be admitted under proper regulations and restrictions, and the portion of the area farthest from the intake or diversion may be opened to campers, tourists and fishermen.

If the area is flat agricultural land with gentle slopes toward the main stream or lake, it may be sufficient to acquire a marginal strip of 100 yards or less along the shore of the lake or reservoir. In addition to this, highways within this line should, in general, be relocated further back and outhouses, hog pens, barnyards and refuse dumps should be removed from the immediate banks of tributary streams and garbage should be collected and treated or buried so that it will not reach the streams. The territory acquired should be policed and notices should be posted along the nearest highways, particularly at stream crossings.

If the area consists of steep, rugged land from which the water runs off rapidly, particular attention should be paid to villages and dwellings, to prevent crude sewage from washing into the reservoir. Of course, on such land, there is apt to be the minimum of inhabitants and the land will generally be cheap and readily purchasable.

If land is highly cultivated, it will have a larger population of men and animals and consequently be more subject to contamination.

Mr. Paul S. Fox, in his paper "Watershed Sanitation," which appeared in the Journal of the A. W. W. A. (July, 1928, Vol. 20, p. 50) states that the New Mexico code empowers the governing body of a municipal corporation to exercise control over a watershed for a distance of 5 miles above the point of diversion. He also writes: "On the watershed grazing was prohibited, which seems to be next to impossible. It was reduced, however, to a minimum and the improvement from a bacteriological viewpoint was remarkable. The restriction of recreational uses under controlled conditions was effected by ordinances, posting and policing."

Villages.—Small settlements on the immediate shores of the reservoir should be purchased and removed wherever possible. More remote villages and those too large and expensive to destroy must receive especial attention. Their wastes of all kinds must be excluded under the direction and at the expense of the water supply. In some cases, by discouraging public sewers and by inspecting and cleaning middens at frequent intervals, contamination may be avoided. Especial attention must be given to vaults in the winter when the ground is frozen for at such time if vaults are too full, their contents may overflow and reach the water at the first thaw. In some cases it may be necessary to construct a sewage disposal system to care for the sanitary sewage of the place. In all such cases a clear, well oxidized effluent should be produced and chlorinated.

Storm water passing through a village will necessarily carry impurities. Rough filtering or screening may be required and care must be taken not to locate a water works intake within the influence of such storm water stream.

It is better to purchase and remove cottages from the immediate shores of a lake or reservoir. Pending such action a palliative is an efficient pail system.

Use of Watershed.—Certain portions of a catchment area which it may be advisable to purchase, in order to control its uses and occupation, and which can be profitably farmed, may be leased to agriculturists giving first choice to the former owner or occupants. Such rental would be subject to specified conditions under the constant and immediate control of the water supply authorities. This will mitigate in a large measure the opposition of some who do not wish to move from the locality preempted.

Reforesting.—Without doubt, especially in a rugged country, a forest will afford the best cover for a catchment area of a surface water supply. Planting along streams will assist in preventing erosion of the land as well as formation of bars and deltas in the reservoir with the consequent loss of storage. It is well to maintain a bare strip a little above high water mark above which the littoral planting for possibly 100 yd. or more in width may well be of conifers, for leaves of deciduous tress would fall or blow into the water.

It has been suggested that when large tracts are to be reforested, nut trees and shrubs bearing berries be planted to furnish food for birds and other small wild life. Valuable woods such as black walnut flourish in some localities.

Many articles on the preservation of forests have stressed the prevention of erosion, the minimizing of floods and the relative constancy and uniformity of run off from forested as distinguished from denuded areas. These are all arguments for reforesting a catchment area and indicate that a wooded area will make a storage reservoir of

given capacity more efficient by flattening the irregularities of the supply curve. Such a forest should be planted with reference to the exposure and soil conditions best fitted for various kinds and varieties of trees.

Lanes about 50 ft. wide should be left clear as fire stops and where possible these should be so located that they may later be used as roads in lumbering, for it may be anticipated that with the increasing scarcity of timber these trees will, in the years to come, produce a valuable commodity and a considerable income.

Roads. — Good serviceable roads should be provided to make the territory accessible and, if the public is to be admitted, the municipality may treat it, in a measure, as a park and construct good roads, cutting vistas through the trees and running the roads to sightly lookouts where such scenic effects are available. Wayside springs may be developed as drinking fountains for travellers.

Camp Sites.—Where several miles from the point of diversion and limited by the local conditions, camp sites may be established either for automobile tourists or for those who may wish to remain for longer periods. These may be of various types, including parking space for those living in cars, tent sites and floors for those who bring canvas shelters, and forest cabins, more permanent in character, but in general housing a single party. Rustic comfort stations may be provided of the type used in the western parks and described in the U. S. Public Health Service report dated June 12, 1925 (Vol. 40, No. 24, pp. 1248-1258). At such a camp, a water supply should be sufficient to maintain the service and properly police the camp.

Fishing.—There has always been a difference of opinion on the safety and advisability of allowing fishing in a natural lake used as a reservoir. One position is that if boats and humans are excluded from the lake and its shores, they can not contaminate the water, hence they should be excluded and possible contamination avoided. Another group, nature lovers who enjoy the woods and streams and fishing, feels aggrieved at being excluded from their former haunts and are sure they have never harmed a lake as they themselves drink freely of it when on excursions in the neighborhood. It is difficult to see how fishing on the upper 5 miles in a lake 15 miles long where the water after two or three years storage is diverted at the lower end, can injure in any way the supply if proper sanitary measures are prescribed and enforced. The cost of service, maintenance, policing, etc., can be borne by small fees exacted for rentals, fishing permits, etc.

Hunting.—Shooting should in no case be allowed. Government reports state that small game and game birds are being exterminated. The remedy is in providing sanctuaries where they may find food and be unmolested. A large forested watershed incidentally provides such conditions while at the same time the absence of hunters reduces the fire hazard and makes the forest safe and more attractive to the great majority of visitors.

Bathing.—On sanitary grounds only it is probable that a limited amount of swimming in a lake or reservoir ten or fifteen miles away from the waterworks intake would not appreciably injure the supply but from aesthetic considerations bathing should be prohibited as most people are averse to drinking from another's bath tub.

Public Opinion.—The growth of cities and consequent need of public water supplies, and the increasing efforts of the population to escape into the country coupled with the ready means of transportation now at hand, presents a many sided situation which calls for broad consideration and a reasonable co-ordination of the interests involved. A certain public service company's engineer favored the entire elimination of flow over a beautiful waterfall because, based upon the traffic over a bridge below the fall. he figured the wasted water was costing about $5.00 a look. There are cases where an entire water supply might be properly utilized; it would be difficult, however. to convince the public that any private franchise or public use of Niagara power should be allowed to destroy the scenic attraction of Niagara Falls.

The same principle holds in a waterworks property. The supply may be assumed as a public necessity; the creation of the storage provision for compensation water to communities down stream and the protection of the catchment area should be hand in hand as a part of the cost of the proposition. It will usually require but a small additional expenditure to make the territory attractive and afford pleasure to many people.

If the public, made up of individuals, the same ones who eventually pay the bill. are shown consideration and afforded a beautiful forest retreat, distant views of the blue water reflecting sky and shore and a chance for a few of them to fish if they like. a pride will develop in "our waterworks," each one will become a booster and there will be the best possible co-operation in keeping things clean.

Watershed of Rochester. N. Y.—As an illustration of a well managed watershed. a small portion of which has been purchased, we may refer to the present catchment area of the municipal water supply, of Rochester, N. Y. The total watershed now in use is 66.2 sq. miles of which 48 sq. miles is tributary to Hemlock Lake. 12.4 sq. miles to Canadice Lake and 5.8 sq. miles to the Canadice outlet. Canadice Lake lies nearly 200 ft. higher than Hemlock Lake, and the outlet is a tumbling stream running through a quick water shed to the Hemlock outlet. From a low diversion dam in the Canadice outlet channel, a 5 ft. concrete conduit brings the Canadice water into Hemlock Lake from which the present conduits proceed to the city of Rochester about 390 ft. nearer sea level and 27 miles due north.

Hemlock Lake had a natural shore line about 15 miles long. For about 20 years, but little land was purchased and the cottages along the shore were served by a pail system operated by the city. In 1895-6, a strip 200 ft. wide from high water mark was purchased and other lands have been added from time to time. Last year the dyke across the foot of the lake was raised 5 ft. to furnish increased storage and considerable property at the head of the lake was flooded during high water. The total area owned by the city around and on the watershed of Hemlock Lake is 2,617 acres.

On Feb. 6, 1919, water was turned into Hemlock Lake from Canadice Lake. The land acquired in the Canadice Lake watershed amounts to 550 acres, and 350 acres have also been purchased in the Canadice outlet, making a total of 3,517 acres now owned on the catchment area. Patrol of the shores is maintained, and the washing of sheep in the lake, as formerly practiced, has been discontinued. Where formerly barn yards and heaps of waste were located on the banks of runs and ravines, buildings have been constructed elsewhere, partially at the city's expense and the unsanitary conditions thus abated. By closing a road along the east shore of Hemlock Lake a potential source of pollution was avoided. This was made possible by the co-operation of the local highway commissioner who had found this road difficult and expensive to maintain. When the cottages were removed there was no reason for the road, as it was paralleled by another and better road on higher ground.

Canadice water has always been chlorinated before its discharge into Hemlock Lake and since May 11, 1925, the entire supply from the domestic system has been chlorinated at Rush Reservoir, nine miles from the city. Taste or odor due to chlorination is not noticed in the water as the conduits discharge into two distributing reservoirs of a total capacity of 165 million gallons where there is at present over five days' exposure to the air. There is a large fountain in each reservoir through which about 25 million gallons pass daily during warm weather.

The city property at the foot of Hemlock Lake near the gate houses is landscaped and a picnic pavilion is provided and a grill upon which meat may be broiled. There is, of course, ample water supply, and comfort stations and parking space are provided. In addi-

tion to small parties and some organizations from the city, the place is frequented by organizations from the rural country round about. Its free use serves to create good feeling between the local inhabitants and the waterworks authorities.

In 1902 the city of Rochester began planting trees on the shores of Hemlock Lake. Since that time the work has been extended along the shores of Hemlock and Canadice Lakes and on other areas acquired on the immediate watersheds of these lakes. To date nearly 1,500,000 trees have been planted on about 1,250 acres.

Additional Watershed Proposed.—A project for increasing the water supply by a large addition to the present watershed through the construction of a dam in the Honeoye Valley has been approved by the New York State Water Power and Control Commission. The plan will increase the present Honeoye Lake from 4.5 to 15 miles in length and raise its normal surface 30 ft. The watersheds now utilized will be tributary to the new reservoir and form a part of the total area of 187 sq. miles. This may again be increased to 209 sq. miles by storaging water in a high parallel valley and bringing it into the reservoir through a 5-mile tunnel. The new project looks forward to an ultimate supply of 100 million gallons daily. The engineers who devised this plan were Harrison P. Eddy, Allen Hazen and Edwin A. Fisher, and in their report they say:

"A large amount of land will be required. This should be bought liberally to the end that the city may completely control its source of water supply, and hold it free from centers of population that will tend to impair its quality.

"The land to be submerged is mainly the bottom of the old lake valley which is now swamp land, uninhabited, undrained, more or less covered with forest, and not of great agricultural value. All the land to be flooded must, of course, be secured at the outset either by purchase or by eminent domain, and also a certain margin of minimum width around the lake. In addition to this, and somewhat optional, it is our recommendation that the city buy as far as it can at fair prices, large areas of land to protect the quality of the water. In some cases, buying farms that would be inconveniently situated with respect to roads will remove the necessity for building roads leading to them. The land to be submerged must all be secured before the dam is built, but acquiring other areas may extend over a long series of years.

"We believe that the marginal areas bought and held should be much wider than have been taken in the past, to the end that the great new lake to be now formed may be completely protected in its sanitary quality for water supply for all time."

It has been estimated that the land eventually taken will amount to between 30,000 and 40,000 acres. The southern portion of the territory is more rugged and excellently suited for forest. It is proposed to exclude the public from the shores of the northern part of the reservoir, while it has been suggested that the southern portion might be used more liberally while at all times being kept under careful supervision.

The elevation of the proposed lake or reservoir surface will be +830, while some of the country which it is proposed to acquire rises to elevation +2200. Beautiful views may be had from present and future roads. The farthest limit of the watershed is but 40 miles from the city as the aeroplane flies and the round trip by highway from Rochester around the reservoir may be accomplished through 90 miles of varied scenery in a few hours.

Aerial Survey.—For the purchase of so large an area and because of the difficulty and expense of surveying such rough and wooded country and mapping it in the usual way, an aerial survey and photographic map was decided upon. There were 529 original 8 in. x 10 in. negatives made at a scale of about 1,000 ft. per inch flying at 12,000 ft. elevation. These pictures will be "laid" and the map enlarged to a scale of 800 ft. per inch. Greater enlargements may be made of any details up to 100 ft. per inch. The weather was very uncertain, some re-flying was necessary on account of clouds, and it required from May to August, with the plane constantly ready for flight, to accomplish the few hours of photography required for the 205 sq. miles of area covered. In order to give scale to the map, the city has undertaken a first order triangulation survey of the territory, and has placed a series of visible ground marks at known locations on both high and low ground. In the pictures lot lines described in property conveyances are readily identifiable and a net consisting of these lot lines will be superimposed on the photographic map.

In this country a run, ravine, arroya or gully is colloquially known as a "gull." These gulls generally reveal themselves in the pictures as broad crooked lines of trees and shrubs. Forests have a mottled appearance due to tall and low trees while nurseries or plantings of our reforesting show a plain and uniform color due to the trees in the given area being of the same age.

In the protection of catchment areas, we should have a true map to show things honestly as they are. The treatment of the public in reference to the area should be just from every viewpoint. The water should be kept pure and the surroundings lovely as in nature. This will result in good reports of the system so that any virtue in the management will receive the praise deserved.

Acknowledgment.—The foregoing is taken from a paper presented at the Montreal Convention of the New England Water Works Association.

Detroit's $11,000,000 Airport

Construction is well advanced on the airport now being built by Detroit on a $6,000,000 site owned by the city. An additional $5,000,000 was voted at the November election. On the property already owned by the city, consisting of 250 acres in the northeast section of town, extensive grading and draining work has already been done. The first of several runways, 1,000 ft. long and 150 ft. wide, has already been constructed. The last of the concrete slab was placed on June 21. This concrete runway gives access to the southwest section of the L-shaped port and will be supplemented by others, affording take-off and landing facilities in all directions, under all weather conditions.

According to P. A. Fellows, city engineer, contracts have been let for the placing of 20,415 sq. yd. of concrete surface to be used as hangar aprons, taxiways and maneuvering space for planes taking on or discharging cargo. Much of this work is to border the combination exposition hall and hangar, a great steel and concrete building 1,000 ft. long and 200 ft. wide, the cost of which is estimated at $1,000,000.

In plan, the Detroit City Airport may be compared to the famous Croydon port at London, although when finished the Detroit plant will be far more elaborate and convenient. In its completed form, the airport will be featured by a wide esplanade leading motor traffic off of Gratiot Avenue directly to the Administration building, where passengers may buy tickets and obtain other travel services as conveniently as at the most modern railway terminals. Beyond the Administration building there will be a covered concourse where planes may be boarded in safety and comfort, without exposure to the weather.

The exhibition hall will flank the esplanade on the right; an equally large hangar will be located on the left. Every equipment for facilitating air traffic, day or night, is to be installed, thereby assuring both pilots and passengers the utmost in safety and regularity of service.

Four Massachusetts Water Properties Sold.—Community Water Service Co., through a subsidiary, Greenwich Water and Gas System, Inc., has acquired the water properties serving Dedham, Hingham, Scituate and Cohasset, Mass. The companies acquired are appraised at $4,805,900.

Prechlorination and Filtration

Experience at Plant of Newport News, Va.

By E. F. DUGGER
General Manager Newport News Water Works Commission, Newport News, Va.

OUR city is very fortunate in that the drainage area of our reservoirs is to a great extent uninhabited and covered with woodland, which gives a three-fold benefit:

1st. Contamination is minimized.

2nd. A uniform runoff.

3rd. The trees or woods serve as a wind break and by this means decreases evaporation.

There are two elements that prohibit deep storage in our section of the peninsula, first, the general low elevation of the land preventing the raising of the dams, and second, the danger of getting salt water from deeper excavations.

General Conditions of Supply.—We have three reservoirs and the one directly connected with the filtration plant, with a maximum elevation of 17.4, has a storage capacity of 844,000,000 gal., which without the normal yield from the surrounding watershed, will allow approximately 200-day supply based on our present consumption. With this number of days supply impounded, a great amount of sedimentation takes place in the reservoir.

Lakes or impounded streams such as we have are the natural primary settling basins, and with the extended storage in our lakes much of the matter in suspension has sufficient time to settle out in the lakes. This process, however, is of varying degrees of excellence, because of the effect of wind currents on the water, at times the silt or sediment in the reservoir is stirred up and again is put in suspension. On account of the flatness of the surrounding country, it is imperative to keep the springs and streams clear of leaves and sediment, as the water in these streams moves with such low velocity that sedimentation takes place to a great extent in them, and when the heavy rains come, unless the streams are clear, much of this sediment is washed into the lakes and considerable trouble arises from high color caused by tannic acid. As the result of systematic clearing of the springs and streams the water is usually very clear. The raw water average color is around 30, with an alkalinity of 85, turbidity of 10 p.p.m., and a bacterial count of 250 colonies per c.c. which makes a comparatively easy water to coagulate, settle and filter.

The introduction of coagulants in the raw water just ahead of its passage through the centrifugal pumps has resulted in a very thorough mixing of the water with the solutions.

Chlorine is first applied to the raw water in the suction line at the rate of from .3 to .4 p.p.m. prior to the application of alumina sulphate. This latter is applied at the rate of 9 to 10 p.p.m. The coagulation basin has a capacity of only 651,000 gal., but the rate of flow of the water through it is regulated by the use of baffles. The precipitate deposited in this basin has shown conclusively the great value of prechlorination. Before our adoption of this method it was not necessary to clean the basin more often than once in five or six months, but since we began prechlorination, the basin has done the work for which it was designed so much more effectively that it is necessary to wash the basin at least once every 30 days, even in the cold weather, else the precipitate becomes so heavy that it breaks up from the bottom and floats on to the filter beds. Previous to prechlorination the filter beds were compelled to do the work now done in large measure by this coagulation basin which necessitated excessive washing and continuous boosting.

After sedimentation the water flows from the basin by gravity on to eight rapid sand filters of 1,000,000 gal. capacity each, under which is located the clear water well with a capacity of 235,000 gal.

On Jan. 1st, 1923 we felt that our filtration expense was unusually large compared with the results obtained. During the year 1922 the annual output of the filter plant was 1,568,000,000 gal. of water, at an expense, which included the wash water, of $19,664 or $12.53 per million gallons. During this period from January through November we were using 22 per cent alum. But for the month of December, for experimental purposes, we used 17 per cent alum, and the floc obtained with this 17 per cent coagulant was far superior to that which we were obtaining with the 22 per cent, and this item alone meant a considerable reduction in our operating expense.

Results of Prechlorination. — In August, 1923, after the recommendation of A. L. Gammage, Consulting Chemist of the firm of Weston and Sampson, of Boston, Mass., we began prechlorination with the immediate result of a much finer and denser floc with a still greater reduction in the amount of alum. In a short time we also noticed a material increase in the length of filter runs, a decrease in the percentage of wash water and an increase in gallons of water filtered, and a material decrease in the bacterial count in the applied water.

Prior to prechlorination we had considerable trouble with our filter beds. At the end of practically every run cracks would appear in several places in the beds and in several instances the sand would actually pull away from the sides. In washing, hard spots would be visible over the bed which would necessitate considerable labor expense in breaking them up. This trouble has now practically disappeared and the filter beds have a smooth surface with very rarely a hard spot.

We use two independent chlorination plants at all times and this naturally gives us greater assurance of perfect results in the disinfecting process.

The long reacting period of coagulation basins and the chlorine absorbing capacity of the filter beds at most plants permit relatively large overdoses of chlorine without having free chlorine in the filter effluents. This is of practical value, in that when the rate of filtration is lowered it is not necessary to reduce the amount of chlorine applied as the beds will absorb all excess. In fact, the dechlorinating capacity of the filters makes the preliminary chlorination of the raw water comparable to superchlorination.

Comparison of Results.—Table I is a comparison of results in the filtration department for the year 1922, which was prior to prechlorination, with that of 1928.

Costs.—The total expense for the operation of the filter plant for 1922 as previously stated, amounted to $19,664.15 or $12.53 per million gallons. Total operating expense of the Filtration Plant for the year 1928 was $11,570.44 or a total cost of $7.65 per million gallons, which was a net saving in operating expense of $8,093.71 per year or $4.88 per million gallons.

In addition to prechlorination sufficient chlorine is also applied to the filtered water to give a residual of .20 to meet State Health requirements.

The average depth of our reservoir is 8½ ft. with a total flooded area of about 500 acres. With the warm climate the conditions for algae growth are ideal.

Ackowledgement.—The foregoing is an abstract of a paper presented at the First Virginia Conference on Water Purification and Sewage Treatment.

Table I

	1922	1928
Gallons of water filtered	1,568,851,563	1,511,951,662
Daily average	4,292,744	4,142,333
Total pounds of Alum	216,889.77	150,300.86
Total pounds of Chlorine (Raw)		10,518.08
Total pounds of Chlorine (Filtered)	5,863.22	4,083.64
Alum G. P. G.	.964	.69538
Chlorine G. P. G. (Raw)		.0487
Chlorine G. P. G. (Filtered)	.0261	.0189

	1922		1928	
	Raw	Treated	Raw	Treated
Color	0.	10.7	26	10
Alkalinity	61.83	57.2	71.09	63.53

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The Electromagnetic Theory of Air Circulation

In "Municipal News and Water Works," October, 1928, the editor outlined his electromagnetic theory of permanent and migrating cyclones. It was shown that there are 12 permanent cyclonic whirl centers, 6 in each hemisphere, 6 near the equator and three near each pole. The 6 great whirls in the northern hemisphere rotate anticlockwise, while the 6 in the southern hemisphere rotate clockwise. In the article above cited the rotation was erroneously given in the reverse direction.

Each of these 12 permanent cyclones has a corresponding anticyclone, for each ascending whirl bends over and descends, forming an inverted U. This inverted U also characterizes the migrating cyclones that cause our storms.

The editor finds that the three permanent cyclonic whirls whose centers are near the arctic circle, descend as anticyclones somewhat north of the Tropic of Cancer. Similarly the three permanent cyclones whose centers are near the antarctic circle descend as anticyclones near the Tropic of Capricorn. These 6 permanent anticyclone centers lie somewhat to the east of their corresponding cyclonic centers.

In Clayton's "World Weather," p. 40, on a chart of permanent "highs" and "lows" will be found many of the 24 centers above mentioned, and on his p. 19 their effect on ocean currents may be discerned.

It will be noted that this electromagnetic theory of air-whirls and the resulting circulation of the atmosphere differs radically from any theory hitherto advanced. It explains not only the migratory cyclones but the permanent air currents, and it does this without appeal to correction or to differences in centrifugal force on the earth.

The permanent cyclonic whirls increase their intensity and expand in diameter when sunspots increase in number. The ascending cyclonic whirl, being then more powerful, rises to a greater height and descends as an anticyclone at a greater distance from the original cyclonic center, and is also greater in diameter.

Many rainfall paradoxes are readily explained by this theory. For example, the summer monsoons of India bring much rain when sunspots are few, whereas little rain, frequently accompanied by famines, occurs during sunspot maxima.

An anticyclonic whirl that comes from the cyclonic center in the Philippine Islands exists to the west of the latter. In summer it ordinarily causes strong southwesterly monsoons in India, but when sunspots are very numerous its center moves so far westward that these monsoons become very weak. In winter its center moves so far eastward that the northeasterly winds from an anticyclone in Asia predominate. Hitherto this seasonal change in direction of the Indian monsoons has been attributed to convection currents caused by the differences in temperature of the Indian ocean and the land. Similar incorrect explanations have been given of other monsoon winds; for example, those in the United States. Two anticyclonic whirls control these, one centering in the Pacific and one in the Atlantic. The latter is the anticyclone whose cyclonic origin is the whirl that centers near Timbuctoo, Africa. The former has its cyclonic center near the Bering Straits.

The 24 permanent cyclones and anticyclones explain the westward flow of the trade winds within the tropics and the eastward flow of the winds in temperate zones. Also the equatorial calms and those of Cancer and Capricorn are explained thereby.

It should be noted that the permanent cyclonic whirls are whirl-belts, and that relative quiescence exists inside these belts.

In addition to the 24 permanent whirl centers above mentioned there are two others, one at or very near each pole. The one centered at the south pole is clearly cyclonic, the barometer being abnormally low in Antarctic regions. The one centered at the north pole is less clearly cyclonic, and this may be due to a stream of descending air that comes from the great Antarctic cyclone.

One of the by-products of this electromagnetic theory of air movement is that it furnishes an admirable explanation of an enigma that has long puzzled geologists, namely the existence of vast ice caps in low latitudes at times when mild weather existed near the arctic circle. The electromagnetic whirl-belt theory explains such phenomena thus: A very great outburst of sunspots would so concentrate free electrons on the earth as to result in greater intensity of all the permanent whirl-belts. Their great expansion would move certain of these belts into low latitudes; while within those belts there would be relative calm. We see just that condition today inside the whirl-belt whose center is near Timbuctoo, Africa; for there the calm is so extensive that winds do not sweep inward either from the Atlantic or the Mediterranean. It should be noted that this African whirl-belt is the most powerful of all, judged not merely by its present diameter but by its diameter when it raised the mountains that flank the Pacific slope of North America. In the latter case, it was a molten whirl-belt of cyclonic nature that produced this vast crustal uplift, as outlined in the article above mentioned.

For a century meteorologists have complacently dismissed from serious consideration all suggestions that electrodynamics is much of a factor in their realm. Facts, however, point more and more strongly toward electromagnetism as being the greatest of weather factors. This will become increasingly evident in a forthcoming series of editorial articles in this magazine.

Some Remarks on Logic

Two of the oldest—perhaps the two oldest—sciences are mathematics and logic. In some respects they are closely related. In fact all of syllogistic logic can be expressed in the form of equations that serve as premises and are combined to produce the conclusion of inference. However, there is much more to logic than the syllogism, much more than a science of the use of words as a tool of thought. Yet even if there were no more than its verbology, logic would be well worth studying as such.

A part of logic is learned as a by-product of other studies. The same is true of mathematics, yet it is seldom urged that all of mathematics should be learned thus. It is rather surprising, therefore, that there is such a general belief that logic need not be studied as a science by itself. Perhaps the main reason for the prevalence of such a belief is to be found in the character of the text books on logic. Among the best of these is Bain's "Logic," a 700-page book, published by the American Book Co. Written 60 years ago by Alexander Bain, professor of logic in the University of Aberdeen, it is as good as any later treatise written for the beginner. Although all other sciences have marched many a league in the past 60 years, logic has virtually stood still. This very fact points toward some defect in the science of thinking, and perhaps it is the very defect that has led to its decadence.

Herbert Spencer rightly contended that logic should teach certain broad principles relating to matter, for reasoning relates mainly to matter. But practically all logicians have erroneously followed Hamilton's dictum that logic is concerned only with certain laws of thought and their application. Moreover, if there are any laws of thought relating to research and invention, which Hamilton doubts, the logicians are almost unanimous in declaring them not to lie within the province of logic. So, logic, as thought, simmers down to a sort of glorified grammar, which, however useful, is deadly dull. Even as to its utility, doubts may arise; and many a philosopher has vigorously expressed such doubts. Bacon ridiculed the barrenness of Aristotelian logic, and he was not the first to do so, nor by any means the last.

Niell, following Bacon, undertook to reduce inductive (or research) thinking to rules; but did little more than rephrase certain rules that Herschel had printed in his "Discourse on the Study of Natural Philosophy." Neither Bacon nor Niell ever applied the research rules that they laid down, so they failed to see how barren most of them are unless guided by certain principles of which they were ignorant, but of which the real discoverers, like Galileo and Newton, were aware.

Now comes a very curious fact, namely that the greatest of discoverers have rarely laid down a single research rule or principle that is not either self-evident or so vague as to be useless. This fact has often been commented upon. In his "Philosophy of the Human Mind" (an admirable book, written more than a century ago) Dugald Stewart said: "But the language of this great man (Newton), when he happens to touch upon logical questions, must not always be too literally interpreted. It must be qualified and limited, so as to accord with the exemplifications which he himself has given of his general rules." Stewart then refers specifically to Newton's erroneous research rule: "I form no hypotheses * * * Hypotheses have no place in experimental philosophy." Newton's every discovery was based upon some analogy, which inevitably led to an hypothesis, even to that grand hypothesis that the "occult force" gravitation extends beyond the earth to every particle in the universe.

Similarly the research rules given by that other genius, Descartes, are almost all either erroneous or self-evident. When two such men make so poor a fist in writing about their methods of research, there seems to be some truth in the common belief that scientific discovery is an art that can not be taught. However, let no one be hasty in coming to such a conclusion. Very often the men who are busiest in some performance, whether manual or mental, are least capable of instructing others.

Dugald Stewart has to his credit a more comprehensive understanding of the most important principle of research than we have found in the writings of any contemporary or predecessor. He points out that scientific hypotheses are usually based on analogies, and that without hypotheses, the research scientist usually makes little progress. Thus he takes issue with Bacon and with Newton, refuting the latter by pointing to numerous hypotheses that guided his experiments. Stewart barely falls short of insisting that all reasoned-out discoveries have been based on hypotheses that were in turn based on analogies. This generalization, we believe, is true, and failure to perceive its truth has immeasurably retarded the progress of science. Whewell, throughout his monumental "History of the Inductive Sciences" and his later works, also just missed this generalization; and missing it, he formulated a very vague and barren hypothesis respecting the nature of research. Neill, in his "Logic," missed it completely; but a contemporary of Niell, and a more original logician, Stanley Jevons, came very close to a full recognition of the use of analogy in forming hypotheses. In his "Principles of Science," p. 283, he says: "Generalization passes insensibly into reasoning by analogy, and the difference is but one of degree. We are said to generalize when we view many objects as agreeing in a few properties, so that the resemblance is extensive rather than deep. When we have two or only a few objects of thought, but are able to discover many points of resemblance, we argue by analogy that the correspondence will be even deeper than appears." Notice that Jevons says "many points," instead of saying "one point" of resemblance. He just misses seeing that any two phenomena that resemble one another in one respect invariably have other points of resemblance, hidden, it may be but discoverable if we will but follow up the clue furnished by the one point of resemblance.

Jevons (p. 286) says: "There can be no doubt that discovery is most frequently accomplished by following up hints received from analogy, as Jeremy Bentham remarked." Again Jevons fails to see the generality of this rule, or he would have said "always" instead of "most frequently." He is speaking of scientific discovery, and not of accidental discovery; but even accidental discoveries in the realm of science are rarely made by men who have not already formulated some hypothesis, whose truth the "accident" suddenly makes more probable or perhaps certain.

W. P. Gillette

Book Reviews

"Governmental Purchasing," by Russell Forbes, Secretary, National Municipal League; Sec., Governmental Research Association, etc. First edition, 370 pages, 6 in. by 9¼ in., cloth cover, hard binding. Harper & Brothers, New York, publishers. Price, $5.00.

This volume represents a five year study of the functioning of purchasing systems in the federal, state, county and municipal governments of the United States and Canada. No attempt has been made to recommend a "model" purchasing system or to devise "model" forms for its administration because the widely varying legal requirements and local conditions demanded peculiar modifications and precise adjustments in the individual government. Instead, the author has attempted to present a synthesis of the best existing practice, illustrated by representative forms in actual use, of each of the various steps of the purchasing system in which the purchasing office plays a role, from the receipt of a requisition or an estimate of requirements from the using agency, to the approval of the claim for payment. As a further assistance to the practical application of centralized purchasing the author has compiled a representative set of laws, examination questions for the selection of a purchasing staff, salary standards, and other data which are presented in the appendices.

"Stresses Statically Determined," by John Clayton Track, Professor of Civil Engineering, Sheffield Scientific School of Yale University, M. Am. Soc. C. E. First edition, 462 pages, 10¾ in. by 7¾ in., cloth binding. John Wiley & Sons, Inc., New York, publishers. Price, $6.00.

This book was designed to give a thorough working knowledge of the theory of stresses in statically determined framed structures. Considerable attention has been given to explanations of fundamental conceptions, principles and methods, thus permitting the student to master them easily and quickly by himself.

One important statement made in the text follows:

"In any general method of attack, whether it be a problem in stresses or a problem in any other type of engineering work, there are three main steps, namely: (1) To determine what is known, (2) to determine what is unknown or required, and (3) to solve the problem by working from the known to the unknown by some correct and efficient method." The author states that in the subject of stresses there are only eight different types of problems which commonly arise: two in concurrent forces, two in parallel forces, and four in non-concurrent forces. He states, further, that any given problem will fall usually under one of these eight cases according to the number and nature of the unknown elements. Hence, the unknown elements well determine the case.

The book is mechanically arranged for the advantageous use of the material in that diagrams which are being discussed in the descriptive matter is usually before the reader at all times without turning pages. All material is excellently arranged. Illustrative problems clearly demonstrate the point under discussion.

"Field Engineering," by William H. Searles, C. E., Late Mem. Am. Soc. C. E. and Howard C. Ives, C. E., Civil and Consulting Engineer. Twentieth edition, 350 pages in text and 386 pages in table sections, 4⅛ in. by 6¾ in., gold edged, flexible binding. John Wiley & Sons, Inc., New York, publishers. Price $4.00.

A chapter on highway curves has been added to the regular handbook in producing this addition. The treatment is not exhaustive and should have been accorded greater length and more discussion to make it the new section of the equal standard with the remainder of the book. No mention has been made of superelevation or curve widening, both of which should receive discussion in the text.

A point of weakness in the book is the lack of an index. There is a table of contents in the front but to be real usable and act as a handbook this volume should contain a detailed index.

"Structural Problems," by C. R. Young, B. A. Sc., C. E., Mem. Eng. Inst. of Canada, Mem. Am. Soc. C. E., Prof. Structural Eng'g. Univ. of Toronto. First edition, 230 pages, 6 in. by 9 in., cloth binding. John Wiley & Sons, Inc., New York, publishers. Price, $3.50.

This book is written with the point in mind that many students and designers prefer to check their understanding of an unfamiliar theory closely following through an illustrated example. The problems presented do not in any sense constitute a treatise or a complete systematic development of the subject, but merely indicate the method of applying elementary structural theory to the design of characteristic structures, members and details.

The reader is assumed to have a sound basic knowledge of statics and mechanics of materials. Consequently the computation of stresses necessary in the design of the structures has, wherever practicable, been dealt with briefly.

Most of the formulae have not been developed. They are stated only and references have been given in places, to standard texts dealing with structural mechanics and the theory of structures. The book is in its nature supplemental to text books on the theory of stresses and structures.

The author states that the following features are new in printed book form:

1. Determination of the net section of riveted tension members.

2. Determination of the thickness of base plates for riveted steel column bases.

3. Computation of the anchorage of columns subjected to overturning.

4. Determination of rivet tension in column brackets and beam connections.

5. Design of a cantilever shelter truss.

6. Design of a stationary jib crane.

Complete design of a timber bent for a flume trestle.

"Chemistry in Medicine," edited by Julius Stieglitz, Professor of Chemistry, University of Chicago, with Board of Advisory Editors. First edition, 757 pages, 5½x7½ in., flexible leatherette binding. The Chemical Foundation Co., Inc., New York, publishers. Price upon application to publishers.

This book presents to the public as well as to the practitioners of medicine the great possibilities for advance in medical science through further intensive cooperation between chemistry and medicine. Chemistry is the fundamental science of the transformation of matter, and our life, from our inception to our return to dust, in every breath we draw and in every moment we live, is indissolubly connected with most complex transformations of matter.

Each different subject in the text has been written by a specialist on that subject. Physician, physiologist, pharmacologist, bacteriologist, pathologist and chemist have united efforts in the production of this excellent volume. The following chapter headings give an indication of the type of contents:

I. The Significance of Chemistry and of Its Methods of Attack on Fundamental Problems.

II. Heredity and Development.

III. The Human Body As a Machine.

IV. The Story of the Discovery of Vitamins.

V. The Conquest of Dietary Diseases.

VI. Chemical Regulators of the Body.

VII. The Policing of Civic Life in the Laboratory.

VIII. The Alleviation of Suffering.

IX. The War on Invading Germs.

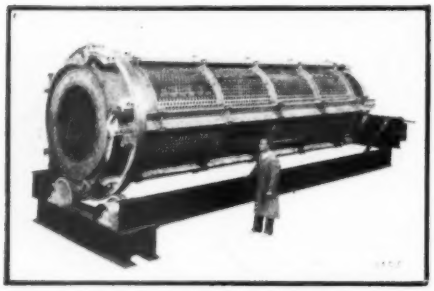
X. A Hope of Mankind—Chemo-Therapy.

"International Airports," by Stedman S. Hanks, Lt. Col., Air Corps Reserve. First edition, 195 pages, 5¾ by 8½ in., hard cover cloth binding. The Ronald Press Company, New York, publishers. Price, $5.00.

This is a discussion of airport construction and facilities told in a narrative style. Various airports of Europe and America are described. Methods of handling passengers and freight are discussed. Lighting, communication, management and insurance are items treated in the book. The many illustrations show airport arrangements much better than word descriptions. The author traveled to all of the principal airports of Europe by airplane. His discussion is the result of first hand impressions.

All Roller Bearing Screens

In the new plant of the Van Camp Sand & Gravel Co. at Lebanon, O., every piece of machinery will be equipped with antifriction bearings. One of the screens, a 72-in. Telsmith-Hercules, built by the Smith Engineering Works of Milwaukee, Wisconsin, is



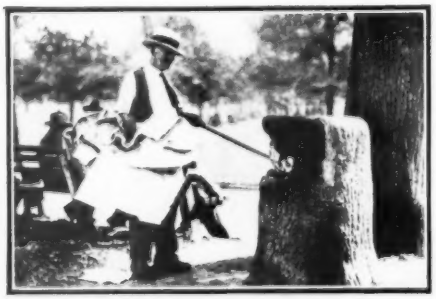
New Telsmith Roller Bearing Equipped Gravel Screen

equipped throughout with Dodge-Timken roller bearings and has a capacity of 300 cu. yd. of sand and gravel an hour. It has an extra heavy frame, all gears are enclosed and special protection is provided for the bearings.

The Van Camp plant, which is rapidly nearing completion, will have a daily capacity of 3,000 cu. yd. of washed sand and gravel. The 72-in. screen will be used as a scalper to precede two 60-in. Telsmith-Hercules washing screens, one of which will be used for classifying gravel and the other for the production of crushed stone. Arrangements are provided for diverting the flow of material from one screen to the other as may be necessary. These two 60-in. screens are also being built by the Smith Engineering Works and equipped with Dodge-Timken roller bearings.

Concrete Tree Trunk Park Incinerator

To eliminate the objectionable feature of daily collecting rubbish from refuse cans and to provide a receptacle rather more attractive than the usual refuse container, there has been developed a reinforced-concrete incinerator, designed to resemble the trunk of a tree. They are in use in a number of cities, about 350 of these incinerators having been placed in Central and Riverside parks in New York City. Each receptacle is provided with a grate at the bottom, so that the park attendant merely burns the contents each evening. There are two holes directly under the grate to permit draft and to allow removal of ashes. The interior of the incinerator is lined with fireclay. These incinerators have been developed by the Municipal Products Company, Grand Central Terminal Building, New York City.



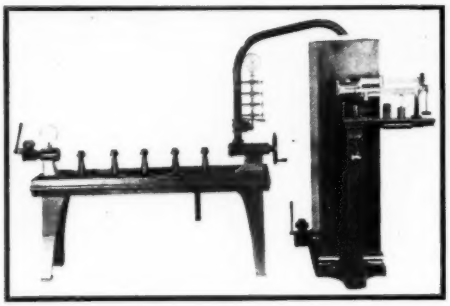
Tree Trunk Type of Incinerator of Reinforced Concrete

Clark Meter Testing Machine Improved

A slight change has been made in the Clark Meter Testing Machine for testing the accuracy of water meters.

The electric alarm bell which has been used to signal the closing of the test on water meters has been replaced by an electric buzzer. In several cases where the Clark Meter Testing Machine was located near the telephone, it was difficult to distinguish between the bells.

The electric buzzer on the Clark



Clark Meter Testing Machine

Meter Testing Machine is quite an aid in the testing of meters on small flows.

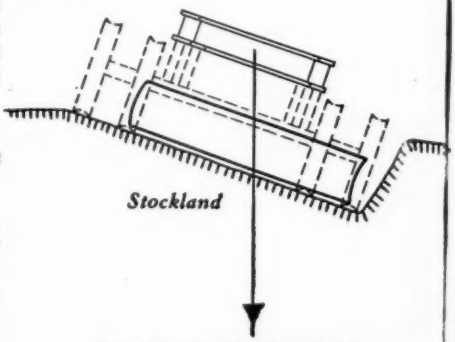
In testing on a small flow or on quantity tests for accuracy, the operator may leave the machine and occupy himself with other duties. The electric buzzer calls the operator a few seconds before the close of the test.

Stockland Improves Grader

One of the design features of the Stockland road grader is its low center of gravity with plenty of blade clearance. This, the manufacturer states, is strictly a Stockland feature which has been carefully worked out by the engineers who are constantly working to give the users of road graders efficient equipment.

Because of this low design, it might appear that there would not be enough blade clearance. It is claimed, however, that all Stockland graders have a blade clearance equal to graders built higher from the ground, and yet have all the advantages of a low center of gravity design. The circle assembly can be raised the full height of the frame if necessary.

The center of gravity comes directly through and very close to the center of the cutting blade when on a 2 to 1 slope. As the design of a grader is made higher, the perpendicular line drawn from the center of the grader frame down through the blade will come correspondingly closer to the outside edge of the blade instead of the center when on a slope.



The Improved Stockland Grader

Some of the other design features claimed for the Stockland grader are the cut-lift-roll curved blade, proper location of blade, extra long wheelbase, three-point suspension, fewer working parts and heavy frame construction. All of these interesting features are dwelt upon in the new Stockland S-10 Grader Book.

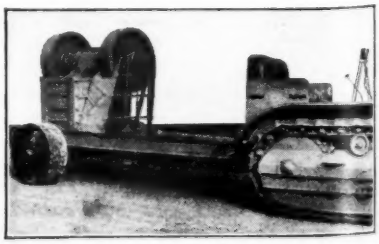
Foote Bros. Gear & Machine Company, 111 N. Canal St., Chicago, Ill., who have recently taken over the Stockland Road Machinery Company, Minneapolis, Minn., will be pleased to send you one of these Grader Books upon request, without obligation.

Tractor Drawn Crusher Announced

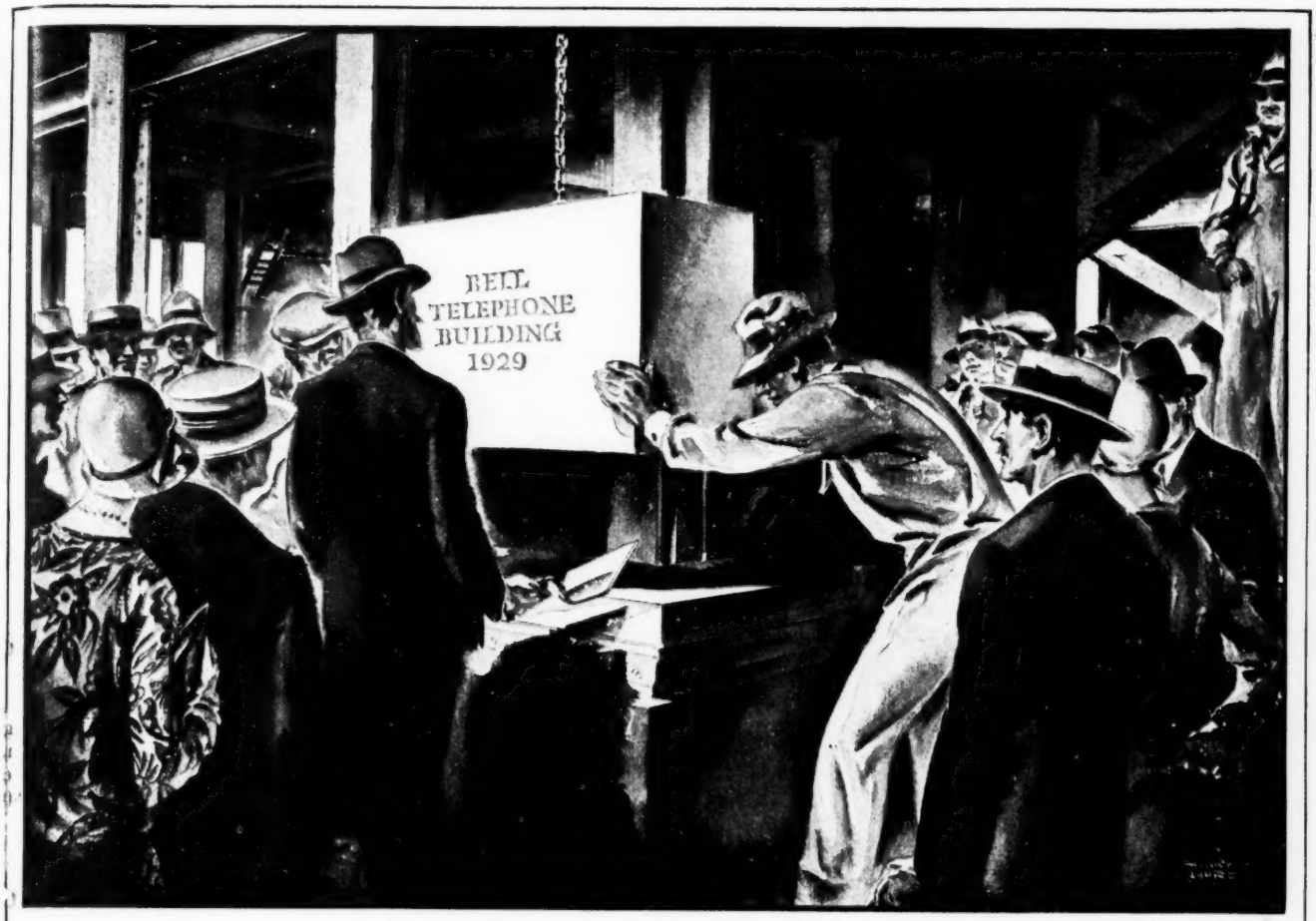
The new Day Jaw Crusher, manufactured by the Day Pulverizer Co., of Knoxville, Tenn., is driven direct from a Caterpillar power take-off.

It can be attached in two minutes as the drive assembly has two universal joints and there is no delay for alignment. It is fed from the side and may be moved forward as it crushes.

Adjustments are easily made for any size material while the machine is in operation. With its short turning radius, simplicity and ruggedness of construction, it provides to counties and various others a most economical machine as it provides crushed materials right on the job.



New Day Portable Jaw Crusher



THE BELL SYSTEM IS BUILDING AHEAD OF THE GROWTH OF THE COUNTRY

This is the telephone's job and goal

An Advertisement of the
American Telephone and Telegraph Company

THE United States is developing a new civilization. The telephone is an indispensable element in it. The Bell System is building ahead of the growth of this civilization. In 1929 the telephone budget for land and buildings is 54 million dollars, with new buildings rising in 200 cities. New equipment for central offices will cost 142 millions; exchange lines 120 millions; toll lines 119 millions.

The Bell System's total expenditure for plant and service improvements this year will be 559 million dollars.

This outlay is required because the telephone is a universal servant of this democracy. Business uses it to create more prosperity. Homes use it for comfort and protection, for keeping friendships alive and enriching life. Its general use enables each personality to extend itself without regard to distance.

The telephone ideal is that anyone, anywhere, shall be able to talk quickly and at reasonable cost with anyone, anywhere else. There is no standing still in the Bell System.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

R. Emerson Swart, at 28, Elected to Head Large Public Utilities Organization

The Community Water Service Company, one of the largest holding corporations in the United States operating water utilities, announces the recent election of Mr. R. Emerson Swart as president. This honor places Mr. Swart in the ranks of the leading public utility executives at the age of 28 years. He has been associated with P. W. Chapman & Co., Inc., since 1922, being elected a vice-president of the firm in 1925. In assuming the office of presidency of the Community Water Service Company he succeeds Mr. Chapman, who, according to announcement, is to become chairman of the board of directors.

R. Emerson Swart, recently elected president of Community Water Service Company

"Supporting Sales by Service"

Wallace & Tiernan, manufacturers of chlorinators, located in Newark, N. J., many times has been called upon to furnish emergency service in protecting the public health through chlorination of public water supplies. In announcing to water works and public health officials the re-organization of its field forces for more effective sales and service, citation is made of many instances where the staff of this company answered emergency calls.

Notification of the new division and district headquarters of this company in the United States, Canada and Mexico, has been brought to the attention of officials in the field by means of a charted map of North America. This plainly indicates the many conveniently located centers for securing immediate service, and bears the caption "Servicing a Continent."

In the announcement made by Wallace & Tiernan of "Supporting Sales by Service," they point to the specific work done at the time of the St. Francis Dam disaster in California, the Porto Rican hurricane, the floods in the Illinois Valley, western New England and Mississippi Valley and in Alabama, eastern Georgia and Tennessee. Their staff was also found at work in supplying safe water to the British and American expeditionary forces during the World War, aiding hurricane stricken Florida and central Illinois at the time of the tornado.

Air transport now furnishes a new and quicker means of rendering service, and with their headquarters located but 30 minutes distant from the famous Newark Airport, should an emergency arise, their officials announce their ability to ship portable chlorinators by airplane to any part of the United States. Their recent campaign for more effectively covering the field is well named, "Supporting Sales by Service."

Manitowoc Engineering Works, Manitowoc, Wis., will be represented in Philadelphia, Washington, D. C., and Maryland by Mr. H. W. Green, 505 Fox building, Philadelphia, Pa. Mr. Green has taken on the promotion and sale of Moore Speedcranes, shovels, draglines and trenchoes, and the Buffalo-Manitowoc clamshell buckets.

Ohio and Kansas to Have New Prest-O-Lite Plant

Two new plants to supply local industry with dissolved acetylene for oxy-acetylene welding and cutting have been established by the Prest-O-Lite Company, Inc. One plant is located at 540 E. 17th St., Wichita, Kan., and the other at Jones St., and Pennsylvania R. R., Youngstown, O.

The superintendent of the Wichita plant, which commenced operations the latter part of June, is Mr. H. Wilson. The district superintendent for this locality is Mr. W. Webert, with headquarters at the North Kansas City plant.

The Youngstown plant was opened the first part of July, with Mr. A. C. Mattison in charge as superinendent. The district superintendent, whose headquarters are at the Pittsburgh plant, is Mr. C. G. Holt.

Distributor Note

Mr. Fairman B. Lee, sales engineer for the Asbestos Covering & Supply Company of Seattle, Tacoma and Portland, has been east on a trip, calling on several of the large manufacturers represented by his company in the far west. The National Aluminate Corporation and the International Filter Company of Chicago were among the plants visited by Mr. Lee. Mr. Lee's company handles power plant equipment for the A. W. Cash Company of Decatur, Ill.

Foote Perfex Factory Manager

Mr. G. W. Foote has been appointed factory manager of the Perfex Corporation, makers of heavy duty industrial engine cooling radiators according to an announcement made by Mr. D. T. MacLeod, president of the company.

Mr. Foote comes to Perfex from the Republic Metalware Company, Buffalo, N. Y., where for many years he has been general superintendent in charge of production, tools and maintenance. During the war Mr. Foote was connected with the Watertown Arsenal. He also was formerly connected with Geuder, Paeschke & Frey, Milwaukee, Locomobile Company of America and Lake Torpedo Boat Company of Bridgeport, Conn.

C. R. Messinger Elected Director of Gas Light Company

C. R. Messinger, president of the Chain Belt Company, Milwaukee, was elected a director of the Milwaukee Gas Light Company, part of the American Light & Traction Company of New York. Mr. Messinger is also a director of the Sivyer Steel Castings Company, Federal Malleable Company and Interstate Drop Forge Company of Milwaukee, which are affiliated with the Chain Belt Company. He is also a director of the Nugent Steel Castings Company of Chicago. The Chain Belt Company operates a plant in Cleveland, O., under the name of the Stearns Conveyor Company.

Chicago Pump Company of Chicago announces Portland, Ore., territory is now under the supervision of D. R. Munro. 201 Lumberman's Building, Portland.